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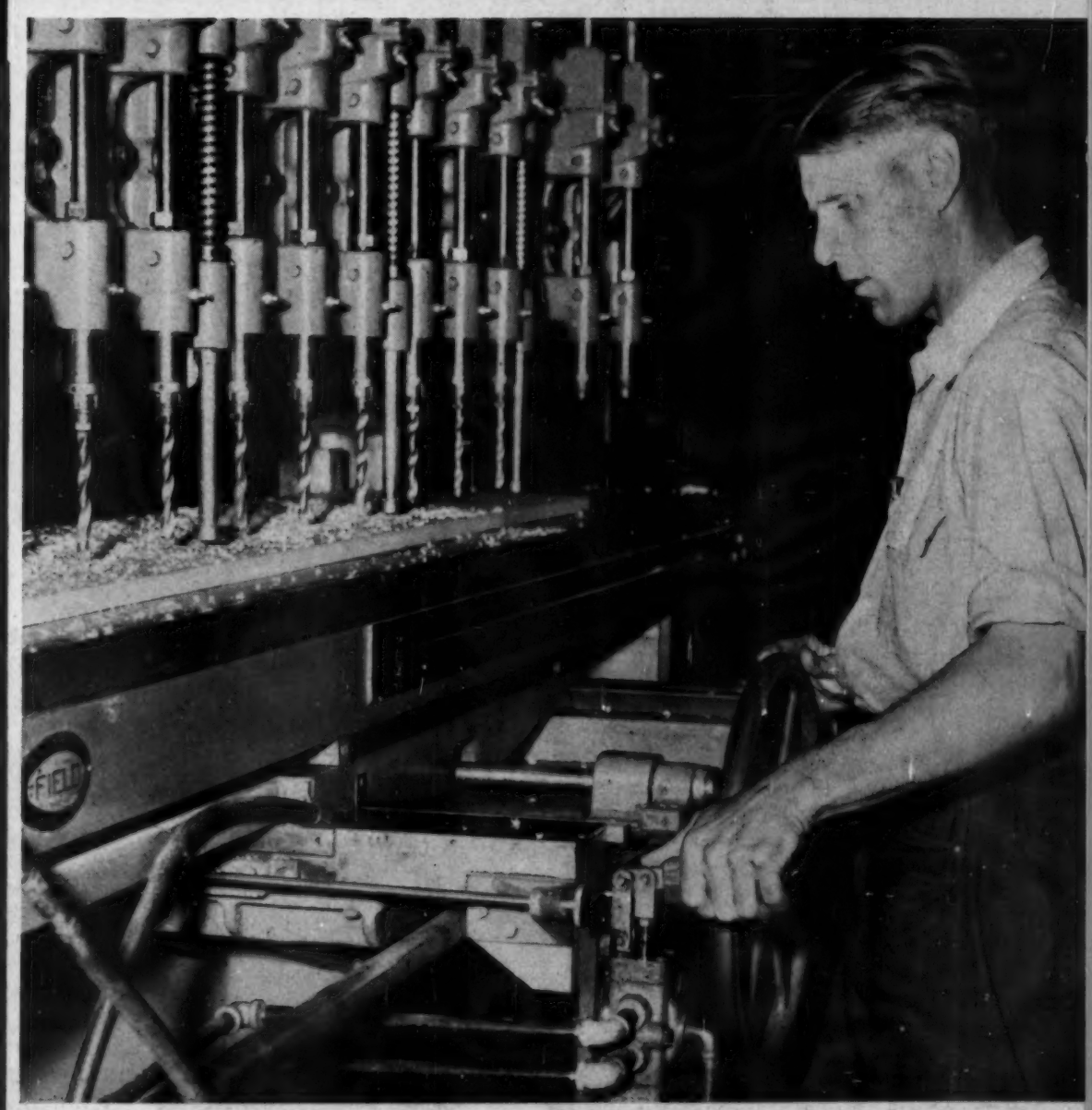
APPLIED HYDRAULICS

THE MAGAZINE OF FLUID POWER TRANSMISSION



IN THIS ISSUE

NEW "HERE'S HOW" DEPARTMENT, PAGE 16
REDUCTION OF HYDRAULIC NOISE AND VIBRATION, PAGE 28

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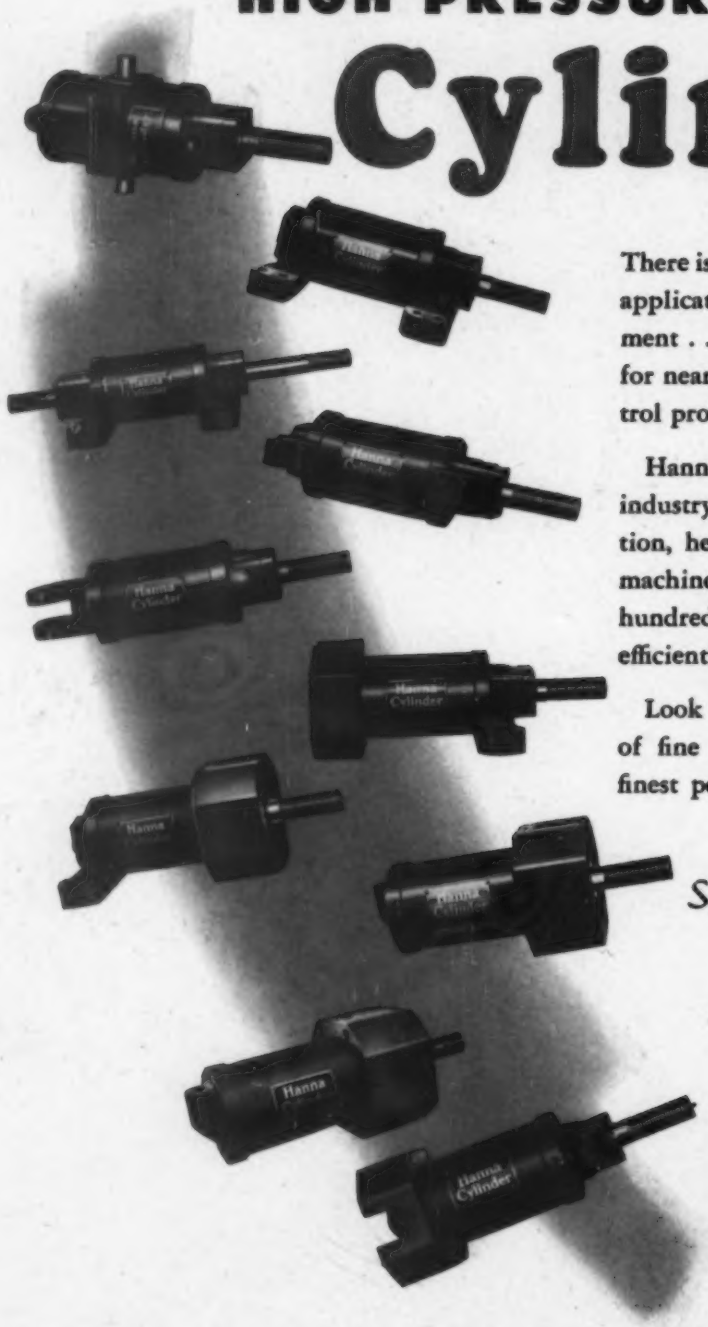

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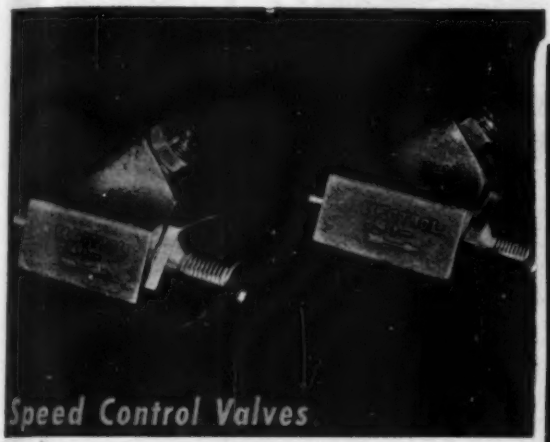

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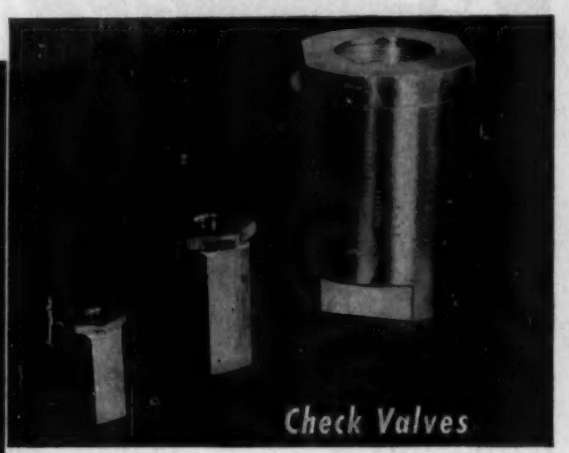

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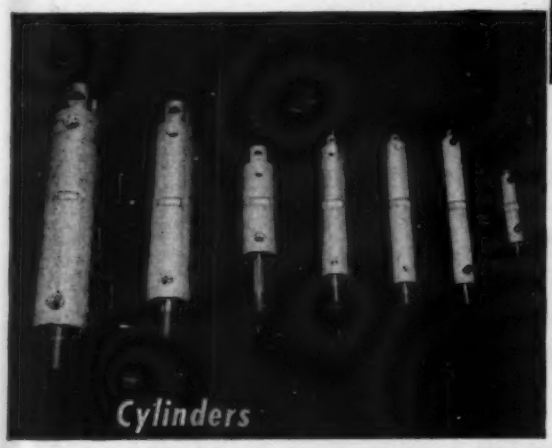

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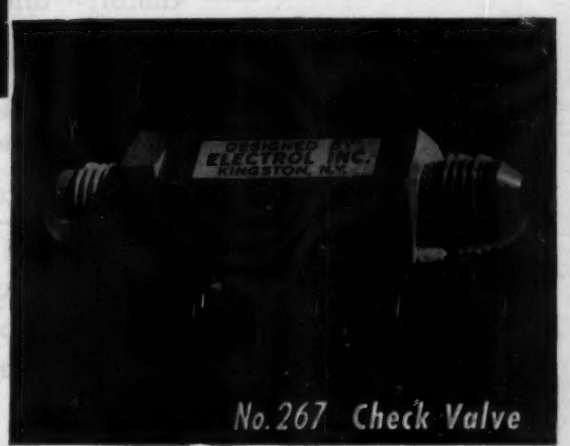

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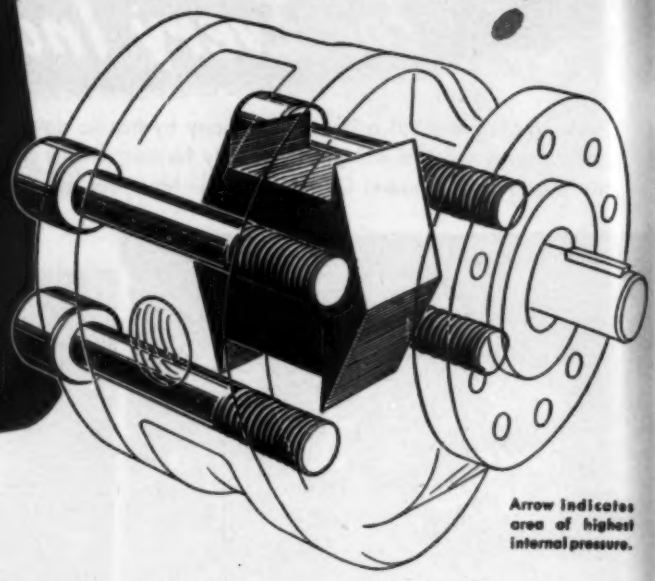
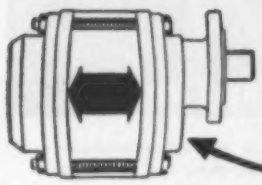
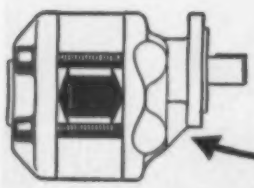


Arrow indicates area of highest internal pressure.



IN THE OLD DESIGN...

of gear pump assembly, housing parts of the pump are assembled by means of numerous bolts or studs located near the outside of the housing. There is **little support** in the pressure area. Housing parts and wear plates distort—uneven wear results and pumps quickly lose volumetric efficiency.



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FRONT COVER: An operator is positioning the table of a multiple spindle boring (woodworking) machine by activating a four-way valve which operates a fluid motor to give automatic positioning and increase production.

APPLIED HYDRAULICS

The Magazine of Fluid Power Transmission

CONTENTS

The Selection and Application of High Pressure Pumps and Fluid Motors 11
By Herb Vickery

Production Calibration of Instruments by Hydrostatic Pressure 14
By Walter R. Ellis

Fluid Motor Steps Up Production of Woodworking Machines 16
By A. J. Polackwich

New Issue of J. I. C. Hydraulic Standards for Industrial Equipment 18

AVIATION HYDRAULICS SECTION
Reduction of Hydraulic Noise and Vibration, Part 1 20
By G. W. Louthan

BASIC HYDRAULICS SECTION
A Beginner's Course in Basic Hydraulics Part 3, Chapter IV 24

DEPARTMENTS

LETTERS TO THE EDITOR 6

HERE'S HOW 29

NEW PRODUCTS 32

USEFUL LITERATURE 38

DIGESTS 39

MARKET PLACE 40

BOOK REVIEWS 42

POST SCRIPTS OF INDUSTRY 46

Published monthly by THE HYDRAULICS PUBLISHING CO., an affiliate of INDUSTRIAL PUBLISHING CO., publishers of COMMERCIAL REFRIGERATION AND AIR CONDITIONING, DIE CASTINGS® FLOW, INDUSTRY & WELDING, OCCUPATIONAL HAZARDS, and THE TAXICAB INDUSTRY. Member, Controlled Circulation Audit, Inc., and National Business Papers Association.

Subscription rates: United States and possessions—$3.00 per year, $5.00 for 2 years; Canada—$4.00 per year, $6.00 for 2 years; Foreign—$5.00 per year. Single copy price, 30 cents. All subscriptions subject to individual acceptance by the publisher.

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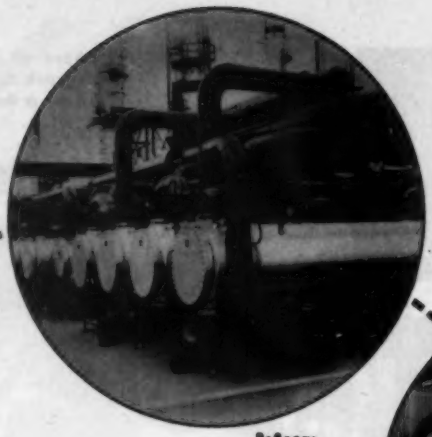
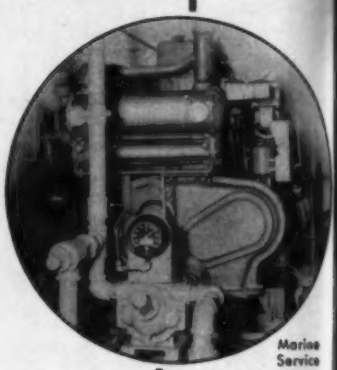
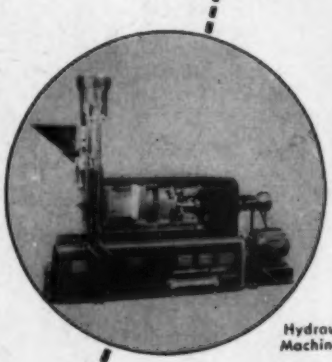


Refinery Exchangers

Engine Coolers



Marine Service



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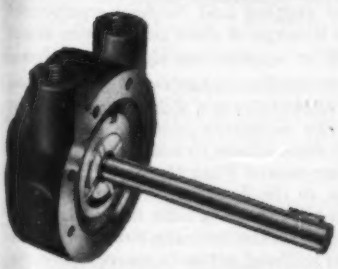

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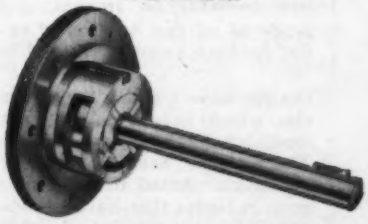

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TEST REPORT

TYPICAL POUR TEST ON MARVEL SYNCLINAL FILTER

This test was conducted to compute engineering data on Model A-1½ Filter.

Conditions of Test

Saybolt Universal Viscosity at 100 deg. F.....319 sec.
Temperature of Oil During Test.....100 deg. F.
Quantity of Oil Used for Test.....5 gallons
Head Pressure.....Pouring

Results of Test

	Marvel Eng. Co. Filter (Mod. A-1½)	Conventional Type Filter
Rate of Flow (gallons per minute).....	33.6**	8.82***

**Twenty-three gallons of oil flowed through the filter per minute; however the conditions of the test allowed only 68.7% of the capacity of the filter to be used. By simple arithmetical calculation, the total capacity of the filter was estimated to be approximately 33.6 gallons per minute.

***Since this filter was full at all times, 8.82 gallons per minute represents its total capacity under the conditions of this test.

*Test by Phoenix Chemical Laboratories.

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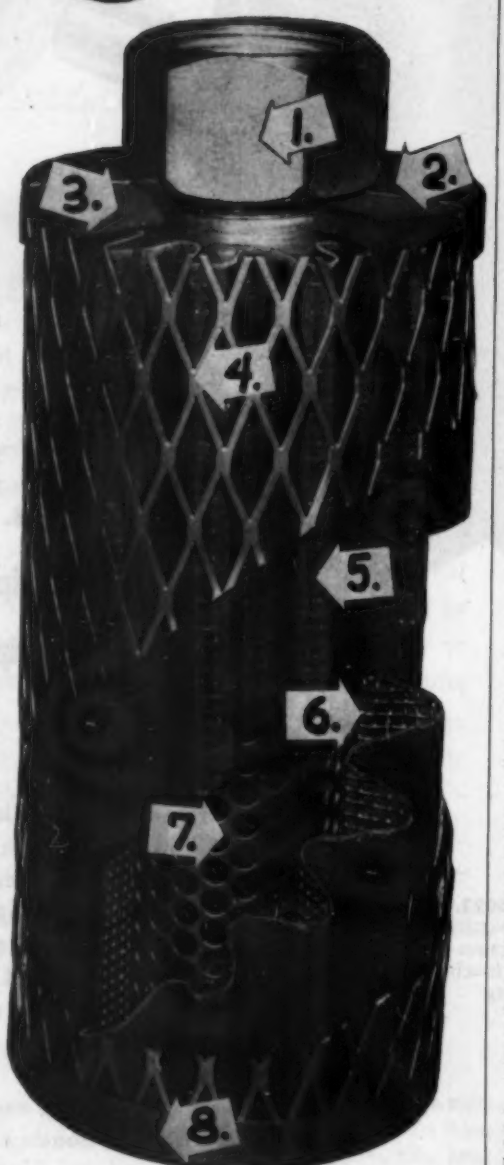

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helpful to you has been prepared by Ransom Tyler of Oilgear Company, Paul Griebel of the Caterpillar Company, Cliff Bonnell of Vickers, Inc., and J. B. Baker of the Ford Motor Company. A course similar to what you have in mind is now being taught by R. L. Hall in the evening school at Fenn College, Cleveland. An outline of this course and specimen lesson assignment sheets have also been forwarded to you.

I like the idea of the "Here's How" department that you have announced for January. If you can, will you "back up" these pages with ads so that, as we clip the individual articles, we won't cut into and spoil a second article that we may also wish to clip. This may be a selfish request but since we get only one copy, we want to get the "most mileage" out of it.

A.D.

We will do our best to keep your clippable articles intact. However, we are also trying to make as much of the editorial content worth clipping as we can, and we can't make definite promises. Occasionally, our articles are reprinted and such reprints are usually available in limited numbers. We also are able to take care of a few requests for tear sheets of articles from issues not over three or four months old.

Could you recommend a high flash hydraulic oil for coal loading machines?

W.G.

We asked several hydraulic oil suppliers for an answer and the gist of the information we gathered is that hydraulic oils commonly used with coal digging and loading equipment has a range of flash point from about 300 to approximately 450 degrees. One supplier suggested a medium oil of approximately 400 flash point due to the explosion and fire hazards of the atmosphere in coal workings. Another stated that the possible openings in the hydraulic circuit with incident leakage of dust laden air made it impractical to make a recommendation without actually seeing the operating conditions. The fact that mention is made specifically of the flash point of the oil leads us to believe that you are particularly aware of the explosion hazard. Your regular hydraulic oil supplier's recommendation can probably be trusted; a better grade of oil can be filtered or clarified for long, safer operating life.

Do you have a check list of the articles which appear in APPLIED HYDRAULICS that have been republished? There have been several articles which we wanted to keep for reference in issues that have become lost and which you write us are exhausted. Such a check list would be very much appreciated.

F.Z.

No, we do not have such a list. However, we did compile a list of the articles which appeared in the first year (February 1948-January 1949) and we will also do the same this year. With a few exceptions, we cannot supply back numbers older than three months.

The Selection and Application of High Pressure Pumps and Fluid Motors

By **HERB VICKERY**
The Rucker Company
Oakland, California

FLUID POWER TRANSMISSION, WITH its smooth acceleration and deceleration, its rapid start, stop and reverse, its infinite speed variation and its automatic cushioning, overload protection and torque control, materially improves the operating characteristics of many machines. High starting, stalling and running torque permits elimination of a great deal of intermediate gearing and, on many applications, permits direct drive. Accurate control of speed, regardless of load variation, and extreme flexibility of installation, which permits hydraulic motors to be mounted in any location regardless of water, dirt or explosion hazard, are distinct advantages in many types of industrial applications, especially on hard to handle jobs. The compactness and high torque and horsepower output for their size, as well as the variety of controls available, permit simplification of construction in many cases. The economy of installation and low maintenance on properly installed hydraulic circuits merit the consideration of every machine designer as well as operating and maintenance personnel.

Modern high pressure pumps, valves and fluid motors, being developments of many years of successful design and operation, are adaptable to present day machines because of their increased efficiency, reduced size and generally improved operating characteristics. Their improved design, which permits sustained operation at high pressures, make them ideal for a wide variety of power applications.

It is hoped that the suggestions that follow will be helpful in selecting and adapting fluid motors in modern machine design.

(In developing his subject, Mr. Vickery reviewed the physical and chemical characteristics of a proper, well selected hydraulic oil; he emphasized the importance of cleanliness in the hydraulic circuit and pointed out the types of filters, strainers and clarifiers available; he recommended adequate provisions—sufficient reservoir capacity, interior water coils and separate heat exchangers—for heat dissipation; and listed the specifications of pipe and fittings for high pressure hydraulic work and gave suggestions on good selection and installation procedure. He emphasized several times the necessity for cleanliness in installation of the hydraulic circuit and its value in preventing delays in production and reducing costly maintenance.)

Dual Vane Pumps and Fluid Motors

Modern high pressure pumps and fluid motors which are to operate continuously under heavy loads at high pressure call for simplicity of design and a minimum of working parts. Not only must the pump be capable of high volumetric output at high pressures, but the fluid motors must be able to develop high horsepower and high starting, stalling and running torque to be applicable on many types of drives. At high pressures the importance of proper hydraulic balance is increased because of the bearing loads and close tolerances involved. The solution of the problems of proper hydraulic balance, bearing loads and proper sealing have permitted the development of present day fluid motors and pumps to a high level of efficiency.

The development and refinement of the dual vane principle of construction in pumps and fluid motors is an example of such an advance in fluid power application. In this

This article is based on a paper delivered at the Semi-Annual Meeting of the Machine Design Division of The American Society of Mechanical Engineers, San Francisco, Calif., June 30, 1949.

Edgar Herbert Vickery, a native Floridan, spent his youth and was educated in the Bay Area. With a wide industrial background, Vickery since 1944 has been associated with The Rucker Company, specialists in the application of hydraulic and pneumatic systems in all types of industry.

type of construction, each vane slot in the rotor holds a pair of vanes instead of one. The vanes are so machined that when they lie together, their beveled edges (Figure 1) form a channel which allows pressure from the inside edges of the vanes to be transmitted to and across the outer edges. A slight chamfer on the outer edges of the vanes seals against the pump or motor ring. The differential pressure created between inner and outer vane surfaces, provides a better seal against the pump ring without exerting a tremendous pressure against the ring. Sealing of the dual vanes, at all positions of the vane in relation to the ring, permits higher volumetric efficiency, even at high pressures. The fact that the vanes act as square pistons and actually do part of the pumping, increases the volumetric output of this type of pump.

The porting of the pump is such that the rotor is hydraulically balanced radially by having two pressure ports opposing each other and two suction ports opposing each other. This is shown schematically in Figure 2. Channels through the body of the pump equalize the pressure on opposite sides of the rotor and the pressure equalizing channels along the sides of the vanes tend to keep the vanes floating between the rear plates on either side of the rotor. This design permits high speed, high pressure operation with very close tolerances maintained between the working parts.

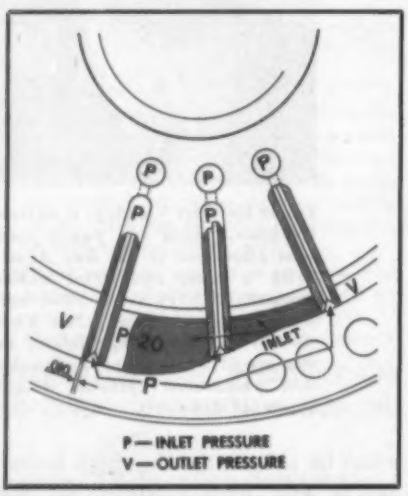

Fig. 1. Sketch showing pairs of vanes in rotor slots, illustrating the method of sealing against the pump ring by a chamfer on the outer edges. The small differential pressure between inner and outer vane surfaces maintains the seal, permitting operation at high pressures.

The torque required to rotate the pump is practically constant and remains practically constant with pressure increases because of the hydraulic balance of the pump. The efficiency of the pump is highest at high pressures and high speeds.

Dual vane fluid motors have the same basic characteristics as dual vane pumps. The sealing provided by the differential pressure principle permits high pressure operation and better distribution of load on the vanes. Since torque in a fluid motor is proportional to fluid pressure, a higher operating pressure gives a higher torque factor in this type of fluid motor. It should be kept in mind that on all fluid motor applications torque is proportional to pressure and rpm is proportional to volume.

Selection of Pumps and Fluid Motors

In selecting a fluid motor for a given drive, the requirements should be carefully calculated and the maximum torque required by the drive must be determined. Since torque is proportional to the vane area and the pressure, this will determine the selection of the fluid motor and also the maximum operating pressure of the pump. The speed of the fluid motor will be proportional to the volume of oil flowing through it and will be limited either by the maximum speed rating of the motor or the maximum volume of oil available.

In selecting a pumping system for a given application, it must be remembered that the pump not only must be capable of developing the maximum pressure required to produce the desired amount of torque in the fluid motor but that it must also be capable of a volumetric output of oil which will produce the required speed in rpm of the fluid motor. Since most fluid motor applications are of the variable speed type, provision must be made either for varying the displacement of the pump or for controlling the volume of oil by suitable flow control valves.

Axial Piston Pumps and Fluid Motors

Recent developments in design and construction of axial piston pumps have made available pumps which will operate continuously at a pressure of 5000 psi on hydraulic fluids as light as AN-VVO-366 aircraft hydraulic fluid, with volumes as high as 35 gpm. Constant volume and variable volume pumps are available, the latter may be provided with any type of pressure or volume control.

One of the outstanding features of the design of this type of pump is the pressure balanced piston shoe (Figure 3) which rides on a film of oil which covers the cam plate. The differential area in the piston and shoe assembly is sufficient to form a tight seal against the cam plate, but is properly balanced to prevent binding. This type of construction has eliminated the heavy thrust bearings previously necessary in axial piston pumps and which have given trouble at high pressures. Since the cam plate is stationary and does not rotate, the source of much bearing trouble has been eliminated.

The drive shaft which rotates the barrel containing the pistons is de-

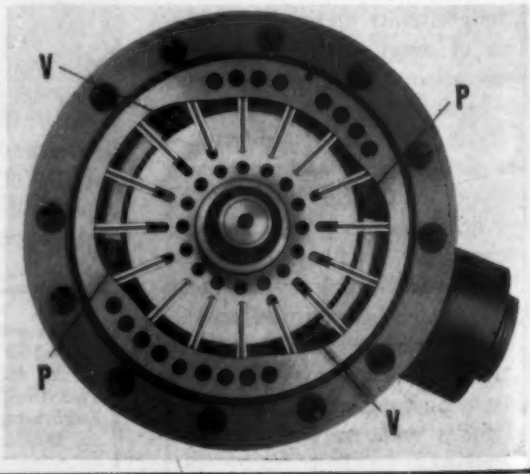

Fig. 2. The vane type fluid motor operates by direct force of the oil against the sides of the vanes. Since two pressure ports and two suction ports are opposite each other, inlet and outlet pressures balance, with no shaft load.

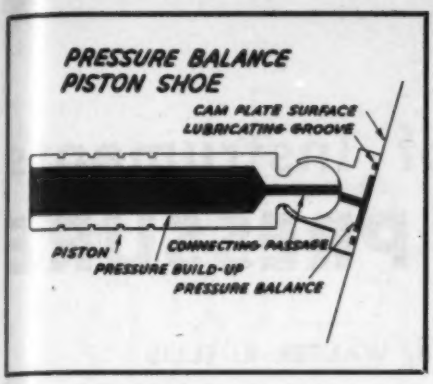

Fig. 3. The pressure balanced piston shoe in the axial piston type of pump rides on a film of oil on the cam plate. The differential area in the piston and shoe assembly permits sufficient force to be applied to seal against the cam plate, but balances the shoe to prevent binding. This construction eliminates thrust bearings.

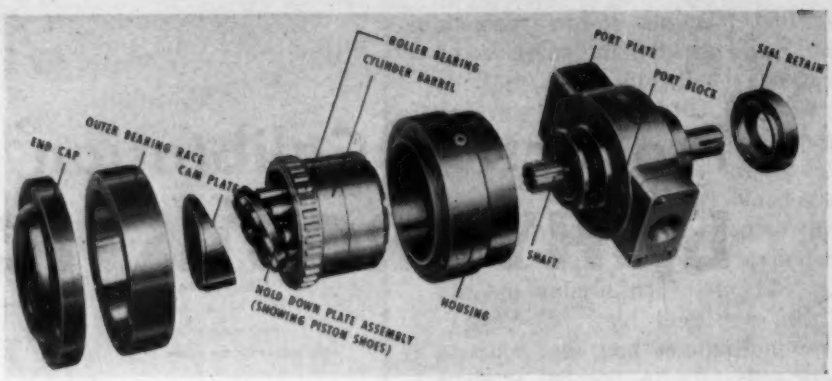

Fig. 4. Exploded view of a typical axial piston pump. The drive shaft and cylinder barrel lie in the same axis; the design is compact, requires few parts, results in less centrifugal force and assures quiet operation at high speed and pressures.

signed to compensate for any shaft deflection and to prevent binding and consequent wearing of parts. Connecting rods have been completely eliminated. The drive shaft and barrel lie in the same axis (Figure 4) and the weight is concentrated around the axis of the pump. The more compact design results in fewer parts, less centrifugal force and a more balanced load at all times. It should be noted that this type of pump is quiet at high speeds at pressures of 5000 psi, indicating a high degree of balance and absence of vibration. The hum of the electric motor will normally be greater than the sound of the pump itself.

(Continued on page 30)

Applications

Applications described by Mr. Vickery in the question period following delivery of his ASME paper.

1. A fruit processor in Oakland, Calif., runs a conveyor loaded with dehydrated prunes through a steam path to prepare the fruit for packaging and shipment. The actual time the prunes remain in the steam depends on variety, size and degree of dehydration. Water content is checked by packer and by State Inspectors and must be held to a definite figure. Prior to installation of the hydraulic equipment, a complicated arrangement of variable speed pulleys, sheaves, belts, etc., were used. These often broke down, causing not only a loss of production but actual damage to several hundred dollars worth of fruit, which had to be redried; this often meant rejection.

By installing a fluid motor on the drive shaft, speed variations from 17 to 790 rpm were obtained, providing a wider speed range and eliminating much of the mechanical equipment. A specially designed tachometer, graduated in minutes of cook instead of rpm and designed to operate over a very wide range, gives the operator direct reading on how long the prunes will be in the cooker for any given length of time. Speed of the fluid motor is controlled by a meter-in flow control valve. The operator merely moves the handle of the flow control valve until the pointer on the tachometer indicates the desired number of minutes of cook and speed is maintained within 1 rpm. This degree of control and simplicity of operation was previously unobtainable.

2. A pineapple canning plant in the Hawaiian Islands installed fluid motors on two long storage conveyors. Power is provided for both motors by a single power unit consisting of a 20 hp motor and a 25 gpm vane pump. Essentially the system consists of a meter-in valve or valves controlling the individual speeds of fluid motors when oil under pressure is supplied from one power unit.

Around canneries the problem of fruit juices with their acid content, sugar, water, etc., makes hydraulic drives desirable. In the operation of this conveyor or conveyors, trucks, loaded with pineapples are dumped, the storage conveyors being loaded as rapidly as possible. The loaded conveyors move the fruit to the canning room at a speed determined by the size, quality and variety of the fruit and the ability of the operators and the equipment to handle. Hydraulics gave a simple and fool-proof method of operating this type of conveyor.

3. A leading manufacturer of portable oil well drilling equipment selected vane pumps and fluid motors to operate their rigs. Pumps supply oil under pressure to cylinders as well as to fluid motors. Fluid motors are used in raising the mast of the derrick and in driving winches. This company is now modifying their circuit and will use more fluid motors for more operations on their rig in their newer models.

4. A fluid motor was installed by the I. W. Johnson Engineering Company at Tacoma, Wash., to power a feed roll drive on an edger in the lumber industry. It is used to drive the rolls which feed sticks of lumber into the edger for cutting to various sizes. The variable speed permits feeding of each piece of lumber at the proper speed considering variety, grade and water content of each piece. Speed of the fluid motor is controlled by a compensator type flow control valve and a meter-in circuit is used. This fluid motor has operated on this circuit for several seasons and, even though the motor shaft is installed with a large overhung load, the machine has performed perfectly.

5. A major fruit canning plant in California uses fluid motors on an automatic box dumping machine. Conveyors, fluid motor driven, carry boxes of fruit to the dumping point; the boxes are dumped, turned over and returned to the box yard. There are three fluid motors on each machine, controlled by valves mounted on a panel and operated by one man, who can dump enough boxes with one machine to keep a large size plant operating. The high torque and positive operation of fluid motors influenced their selection. A large number of workers are on cannery production lines, and any interruption in the flow of fruit or vegetables or any breakdown in equipment is extremely costly.

6. The resaw built by the Northwest Marine Iron Works, Portland, Ore., (described in the March, 1949, issue of APPLIED HYDRAULICS) incorporates a fluid motor driven by a 22½ gpm vane pump. Six heavy cast steel, fluted feed rolls are driven through a gear case and universal jointed shafts. The even feed, unlimited speed variation of the drive has practically eliminated machine shutdowns and, when the cants can be supplied fast enough to keep the resaw loaded, the mill output is increased 30 percent.

Production Calibration of Instruments by HYDROSTATIC PRESSURE

By WALTER R. ELLIS
Compressed Air Products
Newark, N. J.

A simple, economical production test and calibration setup for instruments, utilizing a divided pressure, counterbalanced, air powered hydraulic intensifier to give extreme accuracy, easy, stepless control and protection against excessive pressure.

THE TESTING AND CALIBRATION OF hydraulic pressure recording instruments is generally accomplished through the use of dead-weight accumulators. The accuracy of these instruments make their use mandatory where precise pressure recordings are required.

However, in production manufacture of hydraulic gauges and other pressure recording devices, calibration by means of dead-weight accumulators introduces certain production problems: (1) Pressures generated are not infinite through a wide range but are the result of pressures yielded from the specific sizes of the weights used. For this reason, only increments of pressure are possible. (2) Tests and calibration of instruments are necessarily slow due to the need of employing a number of weights; an intricate, multiple handling of weights was required to provide a range of recorded pressures.

Where an instrument or gauge of known characteristics is used as a master, instruments in production are checked against a master and corrections and adjustments are made on the instruments being tested. This method is in use at Kollsman Instrument Division of Square D Company of Elmhurst, New York, manufacturers of precision aircraft and optical instruments. The dual problem of extreme accuracy and quantity production necessitated a system which would simultaneously solve both problems.

To establish a pressure source for production calibration which would yield a smooth, stepless range of pressures, an air powered hydraulic intensifier was designed and controls arranged by the author, in cooperation with Mr. Joseph Faudree, engineer on the Kollsman staff, to provide a completely controlled system.

The results in absolute accuracy, ease of control and protection to instruments under calibration against over-pressure, have been very gratifying. In addition to the simplicity of the entire system, the overall cost in comparison to that of methods previously used was a factor in the decision to standardize on the system described throughout the Kollsman Division plant.

The line drawing of the intensifier-cylinder unit, Figure 1, is that of the original model—an 8 in bore, 10 in stroke, double-acting air cylinder (of standard manufacture except for piston rod diameter) with the high pressure assembly mounted integrally. The stainless steel piston of the air cylinder is used as the intensifier plunger. The plunger

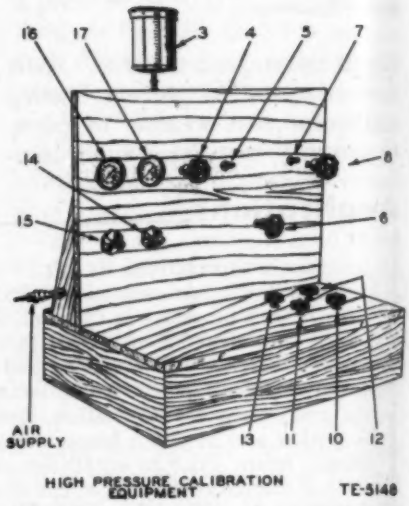

Fig. 1. The original model of the portable test and calibration equipment. The numbers on components correspond to the numbers on the diagram, Fig. 2.

housing is of non-ferrous material, so that water, alcohol and other corrosive fluids, as well as instrument oils, may be used as test media.

The piston rod-plunger extends from the air cylinder into the displacement chamber of the intensifier housing and "V" rod packings are employed to effect a dead-tight seal against pressures to 10,000 psi. Experiments prove that an adjustable packing gland is not necessary when the correct number of "V" rings are used.

With an 8 in bore air cylinder equipped with a 1 in diameter plunger, the ratio of the area of air cylinder piston to that of the plunger is 64 to 1, providing an intensified hydraulic pressure yield of approximately 6400 psi with an air input pressure of 100 psi and with other output pressures in proportion.

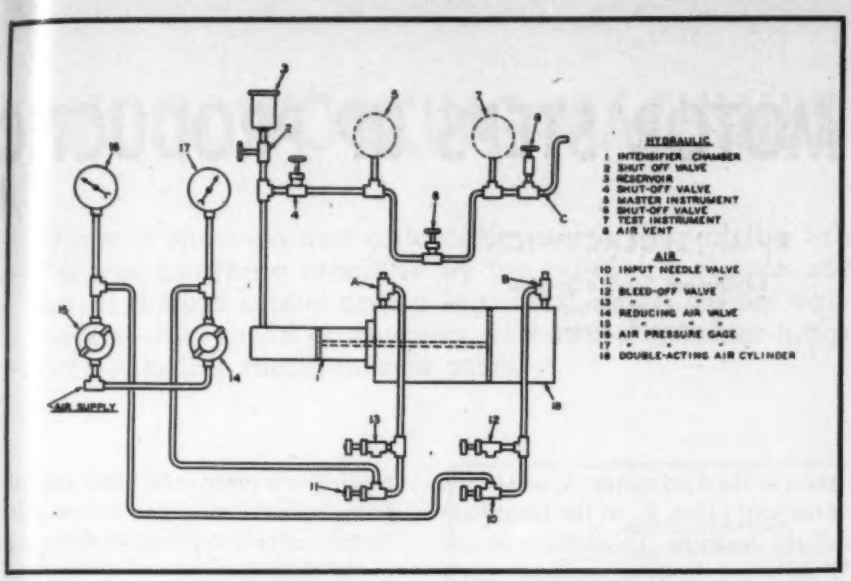

Fig. 2. Schematic diagram of the high pressure calibration system.

As calibrations from zero to maximum yield are required and calibrations at very low pressures are very important, it is obvious that with a 64 to 1 intensifier ratio, low output pressures would normally be difficult to create and control. For example, if 1 psi air pressure is introduced into the push end of the air cylinder, the indicated, theoretical hydraulic pressure yield would be 64 psi, thus by-passing the important low pressure range of 0 to 64 psi.

The schematic diagram of the piping layout, Figure 2, illustrates the final method used to provide the required control of pressure yield at all pressures from 0 to 6500 psi or more. Airline pressure at the system input is divided into two control lines to extend and to retract the intensifier plunger. In each line an air pressure regulator (or reducing valves, Nos. 14 and 15) is installed. Maximum input pressures are controlled so that for any indicated output pressure the yield will not exceed that of a specific gauge or instrument range.

The air pressure regulator, No. 14, which controls the retraction of the air cylinder, is set at a high pressure value to counteract the force exerted by the pressure extending the plunger. Until actual calibration starts instruments cannot be damaged by inadvertantly applied excessive pressure, since the pressure regulator, No. 15, which controls the extensions stroke of the air cylinder, is always set at the lower pressure required for the maximum range of the instrument under test.

The air and hydraulic systems shown in the piping layout are used in a portable test unit designed for use by the Air Force for field calibration of aircraft instruments and clearly illustrates the arrangement of all valves and piping. The circuit shown is the basic system as used for both portable and production units. All control valves are needle type with two degree taper, providing, in addition to extremely close metering, dead-tight closure.

How the System Operates

To place the system in operation, the hydraulic steel tubing fluid lines must be filled with the test medium and all air purged from the fluid system. This is accomplished by opening fluid shut-off valves Nos. 2, 4, 6 and 8 reciprocating the air cylinder through several cycles, drawing fluid from the reservoir during the retraction stroke and pumping fluid into the fluid lines during the extending stroke. Valve No. 2 is closed during the extended stroke. The master instrument and those under test or calibration are previously filled with fluid through a method of evacuation and immersion in the fluid used. The fluid system may be considered as free of air when fluid flows from the top of standpipe "C" (Figure 2).

With all air valves closed, the extended stroke of the air cylinder and intensifier plunger is effected by opening bleed-off air valve No. 13 and metering air into the blind end (bottom) of the air cylinder through metering valve No. 10. To retract air cylinder piston and intensifier plunger, all air valves are again closed and bleed-off valve No. 12 is opened. Air is then metered to the rod end (top) of the air cylinder through metering valve No. 11.

After the fluid lines are filled, pressure tests and comparisons are made as follows: All air valves are closed, high pressure shut-off valves Nos. 2 and 8 are closed and high pressure shut-off valves Nos. 4 and 6 are opened. Bleed-off air valve No. 12 is then "cracked" or opened slightly, bleeding a small amount of incoming air pressure to atmosphere. To extend the intensifier plunger and create hydraulic pressure, a volume of air greater than that being bled off must be metered to the blind end of the air cylinder through metering valve No. 10. As this input volume is increased by the gradual opening of the metering valve, pressure is generated in the fluid system. The slight bleed-off through valve No. 12 acts to stabilize the effective air pressure behind the air cylinder piston.

It is thus possible to generate any hydraulic pressure from 0 to the maximum of the unit through the simple expedient of metering air pressure into the air cylinder. This air pressure, exerted against the cylinder piston, is proportional to the volume of air metered into the cylinder. The exceptionally close control of air flow required for infinite control of intensified hydraulic pressure is made possible by the fine metering adjustment effected by the needle valves used.

The stabilizing effect of the input bleed-off acts to prevent "creeping" of pressure recording. When building up pressure, the metering valve is opened by counter-clockwise rotation of the valve stem. When rotation of the stem stops, the pressure rise also stops and does not fluctuate or creep.

As instruments under test are disconnected, some fluid is lost and the intensifier plunger is moved up to make up the displacement. Eventually the plunger reaches the end of its stroke, requiring recharging of the fluid lines.

(Continued on page 30)

FLUID MOTOR STEPS UP PRODUCTIO F

By A. J. POLACKWICH

Equipment Service Section
Saco-Lowell Shops
Biddeford, Maine

WE WERE VERY WELL PLEASED with our new woodworking hydraulic feed multiple borers on which hydraulic controls were employed to raise the table during the feed stroke and to lower the table on the return stroke. This type borer proved advantageous over the previous borer, which used a mechanical feed, for a number of reasons. The advantages included: (1) increased production; (2) improved quality of work; (3) continuous control of table movement by operator, including stopping or reversing of table at any phase of the feed or return stroke; and (4) automatic adjustment of feed rate to resistance of bits, permitting rapid approach to the work and normal feed while drilling.

However, it was soon noted that further advantages could be obtained from these machines if a method of automatically positioning the table was possible, especially for boards in which multiple rows of holes had to be drilled. As the machine stood, the positioning had to be done manually and the operator was not able to maintain a constant pace throughout the day due to fatigue resulting from the continual turning of the handwheel in positioning the table. It was decided to apply some type of drive to the table lead screw (see Figure 1) which would not only eliminate fatigue but would be rapid in action and capable of starting, stopping and reversing the table instantly.

After investigating the different drives available, a hydraulic motor was selected as it fulfilled the requirements noted, was more economical and because the power unit to supply oil to the fluid motor was available with the machine.

It was quite a simple job to connect the fluid motor into the hydraulic circuit. Figure 3 shows the positions of the fluid motor, A, and of the four-way valve, B, on the front base of the machine. In addition to the fluid motor itself, we required only a manually operated four-way, open center, self-centering valve. This valve, because it is an open center type, acts merely as a by-pass when the valve is in the neutral position. The circuit diagram, Figure 2, indicates how the fluid motor and four-way valve were cut into the circuit. Another advantage of the open center valve is the fact that the hydraulic motor has a tendency to coast somewhat and thus prevent a jolt or shock which would occur had we endeavored to stop abruptly a large mass moving at a rapid rate. Since the full pump volume is being used, no flow control valve is required for the speed of the fluid motor.

The sequence of operation in drilling multiple rows of holes is as follows:

(1) Operator steps on the start foot pedal, which reverses the directional valve in the main control valve and feeds the table for drilling.
(2) At the conclusion of the feed, linkage automatically reverses the valve, causing the table to return.
(3) The operator positions the table for the next row of holes to be

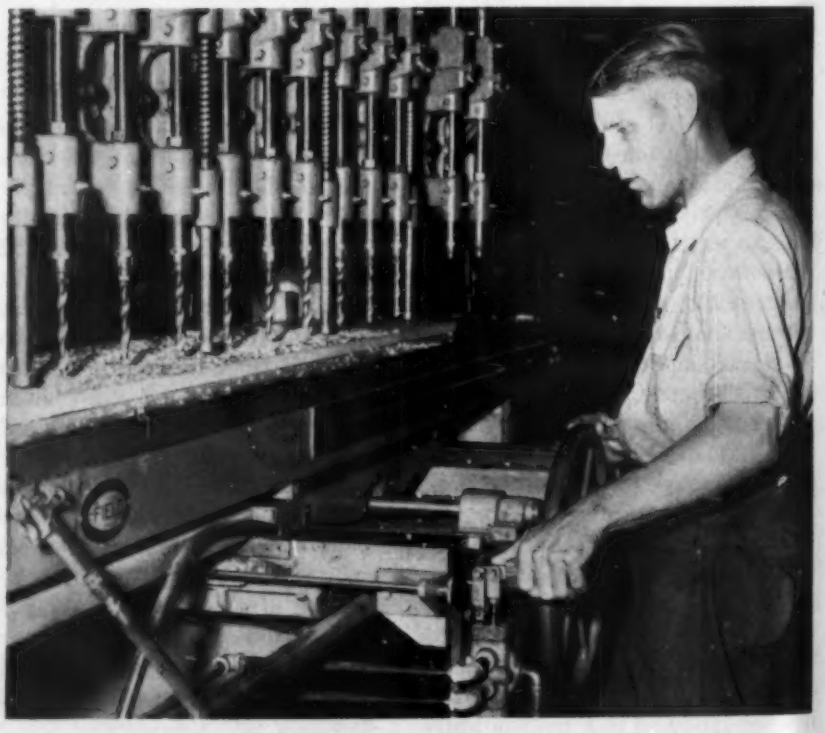

Fig. 1. The operator is positioning the table by moving the lever of the four-way valve. He is watching the scale by which he is able to position accurately.

TIOF WOODWORKING MACHINES

How a shop gained automatic positioning of the table of a woodworking machine by the relatively simple addition of a fluid motor and a four-way, open center valve. Results—increased production, decreased operator fatigue and negligible maintenance costs.

drilled by operating the four-way valve (Figure 1). A scale in front of the operator indicates when the table is positioned correctly.

The use of the fluid motor to position the table has not only increased production, it has helped stabilize our service problem. Maintenance costs have been negligible. The basic advantage that a minimum of moving parts are employed in a hydraulic circuit and that the parts are always lubricated is utilized by our machine repair department to maintain systematic preventive maintenance on schedule. At the present time we are experiencing very little downtime with our hydraulic equipment due, in part, to the cooperation between the oilers and the machine tool repair department. Whenever an oiler notices any discoloration of the hydraulic oil, he immediately notifies his supervisor, who in turn passes this information to the machine tool repair department who take immediate corrective action.

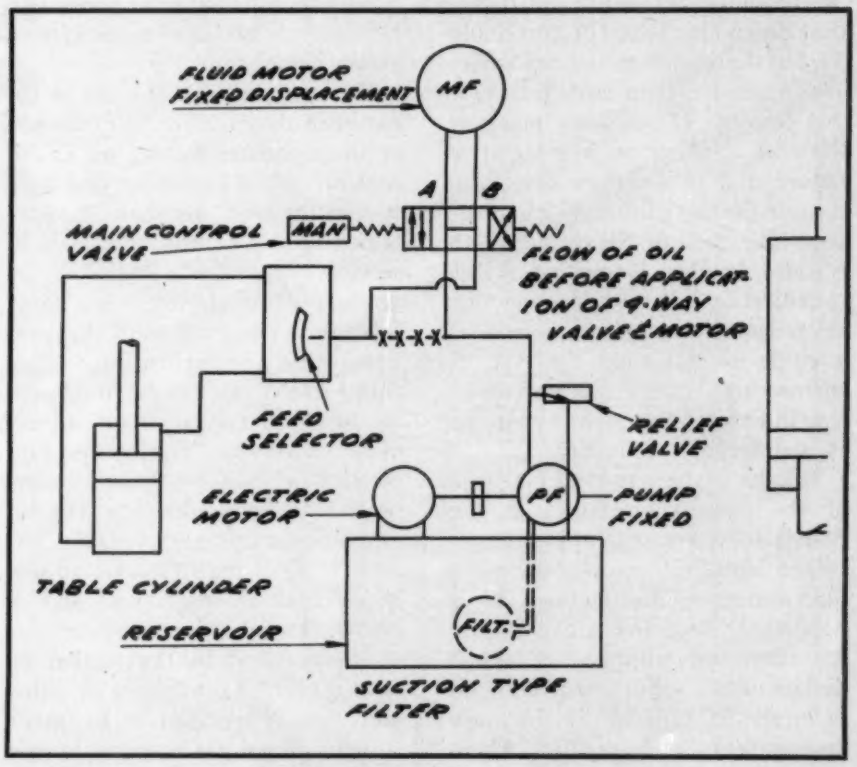

Fig. 2. Schematic circuit of the hydraulic system.

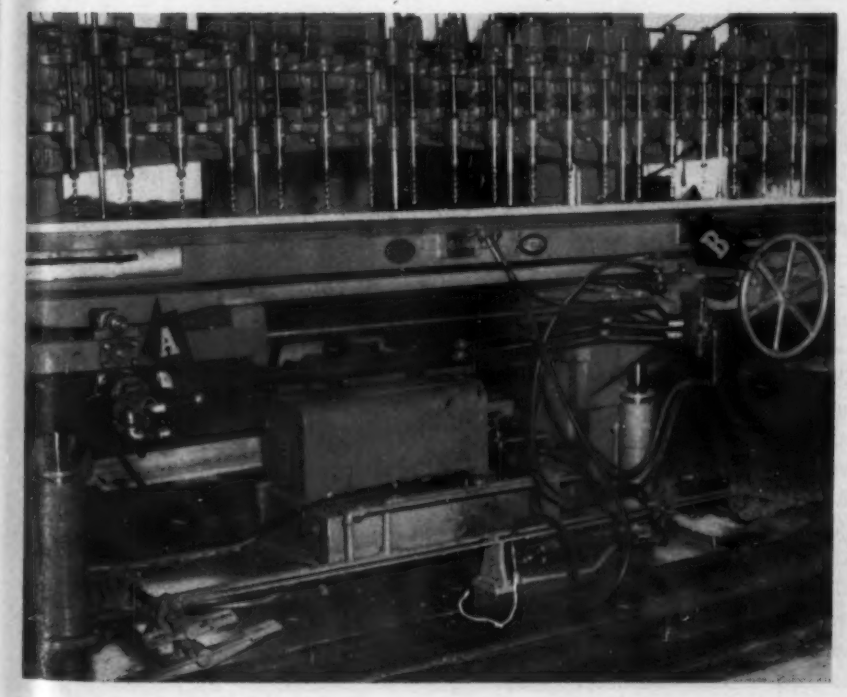

Fig. 3. The front of the multiple borer showing, A, the fluid motor and, B, the four-way valve.

By the utilization of available hydraulic power for additional controlled operations, as in the case of our woodworking machines, plus cooperative preventive maintenance, we have been able to obtain maximum service from our hydraulically actuated production machines.

New Issue of J.I.C. Hydraulic Standards for Industrial Equipment

THE NEW EDITION OF THE J.I.C. Hydraulic Standards for Industrial Equipment issued on November 30, but designated as the September 1949 issue, has been made public.

A total of 22 revisions, many of them of a minor or interpretative nature, and 14 additions have been made in the new edition, which supersedes the first or September 1948 edition. Another innovation is the classification of "engineering developments" which is explained as a guide in indicating the type of engineering that is considered desirable in new developments and in the re-engineering of equipment.

In spite of the very clear language of the general provisions in the Standards, namely that they are concerned with performance, there has been some misunderstanding. This is important, since the standards are not concerned with the individual designs of any one or group of manufacturers or suppliers. Further, new developments on hydraulics, whenever they perform in a manner equal to these Standards are considered equivalent and satisfactory.

Revisions on Diagrams

Among the more important revisions is the group on diagrams and symbols. All diagrams shall carry the sequence of operations as well as symbols, drawings showing functional construction and descriptive text. Two revised sections give a new and more detailed Color Code and Pattern Code for black and white diagrams and a new added section gives functional definitions of various pressures and flows in a hydraulic circuit.

Six new additions have been made on accumulators, which were merely listed in the first edition without recommendations. These additions cover factors of safety in construction, dis-assembly, bleeding and specify information to be added to a permanently attached nameplate on each accumulator.

Some of the revisions are in the nature of clarifications. For example, in the recommendations on circuit controls (H2.4.1) the starting position of the feed rate shall be maintained consistent with the type of service *required* (instead of intended) when shifting from rapid traverse to feed; examples of solderless pipe connections are given (H4.1.6) as flared, flareless, self-flaring, flanged or equivalent, instead of merely stating that solderless pipe connection shall be used; detailed provisions that apply when it is impractical to separate hydraulic and lubricating systems (H0.6); all diagrams shall show (actual) size of piping, instead of recommended size of piping; and in the section on safety (H7.1.4) nitrogen or other inert gas is specified in hydraulic systems where gas pressure is over 250 psi.

Other changes or revisions are in the nature of liberalization. For example, in the section on piping, fittings and fluid passages (H4), paragraph H4.1.6 (f) permits the use of fittings with straight threads and which incorporate seals that seal with pressure, instead of the previous general restriction "on installations in which fitting alignment is important"; the provision that multiple controls shall be mounted on a single plate within one enclosure to eliminate piping (H4.2.5) is changed from "whenever possible" to "whenever practicable"; and in the section on heat exchangers (H5.5) copper or copper alloyed metals in contact with uninhibited petroleum base fluids are prohibited only when these metals are incompatible with such fluids instead of the previous general prohibition.

Two new paragraphs have been added to section H6.2 on sealing devices. One, (H6.2.5), specifies that stuffing boxes for automatic packing shall be designed as to prevent adjustment beyond the functional limits of the packing; the other, (H6.2.6), states that, whenever practicable, heads, slides and actuators shall be designed to facilitate easy replacement of continuous ring packings.

Actuators were added to the last named paragraph and also the paragraph in the section on circuit controls (H2.4) which states (H2.4.12) that circuits having two or more heads, slides or actuators, shall be provided with means to insure all units operating in proper relation, regardless of load variation.

Incidentally, a definition for actuator is the only new definition added to the glossary of terms.

A sample drawing of a hydraulic circuit, utilizing the standard symbols to indicate the nature and function of component parts in the circuit and listing the sequence of operations involved, has been added to the section (H1.3) on standard symbols. The flow condition, to be indicated by color or pattern code, previously mentioned, is defined in a new paragraph in the same section (H1.3) as the condition which is shown closest to the actuating device, as that which exists when the device (directional control valve) is actuated.

Such changes as paragraph H3.3.1 (b) under pumps, "pumps shall not be mounted inside reservoir"; paragraph H4.1.6. (e) under piping, fittings and fluid passages, "all pipe threads shall be Dryseal American (National) Standard Taper Pipe Threads (N.P.T.F.)"; and paragraph H6.3.4 (b) under cylinders and pistons, "cylinders shall be separate, not cast integral with equip-

(Continued on page 29)

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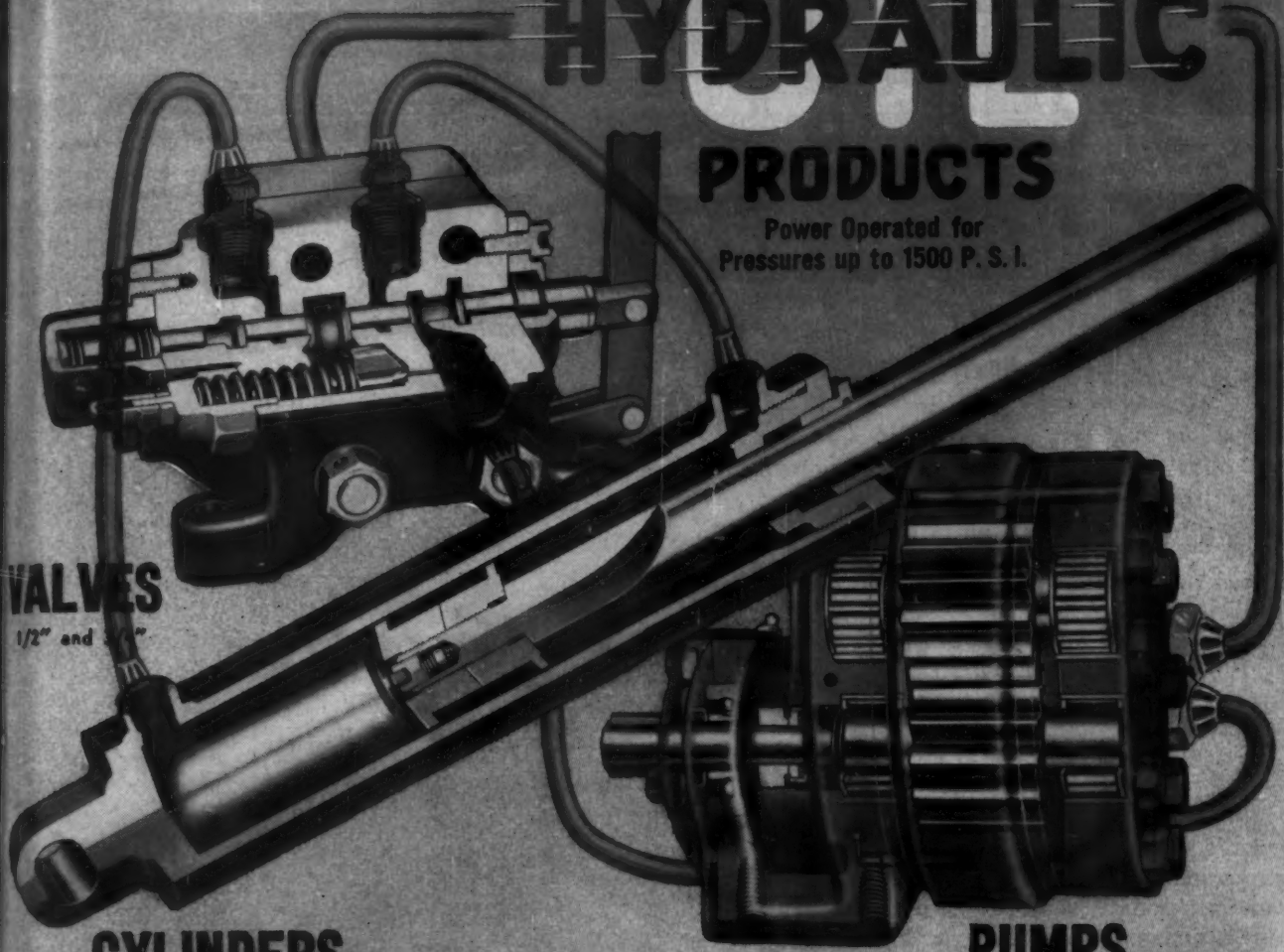

VALVES
1/2" and [illegible]"

CYLINDERS
Capacity up to 50 tons

PUMPS
1 to 75 G.P.M.

LOOK INSIDE—QUALITY THRU AND THRU

At this very moment, scores of machines equipped with hydraulic controls are completely down or operating inefficiently due to some flaw or failure in the hydraulic circuit! Many thousands of invested dollars in these machines are giving little or no return until new hydraulic equipment can be installed or existing equipment repaired.

You will want to investigate the merits of "Commercial" OIL HYDRAULIC Products—tested and proven for over twenty years—never a compromise for quality. Their cost installed usually is a small percentage of the total cost of the machine whose successful operation so largely depends on quality hydraulic controls. "Commercial" OIL HYDRAULIC Products—Pumps, Motors, Valves, Cylinders—comprise a complete line to cover a wide range of applications. Each of these products is engineered and built to complement the others.

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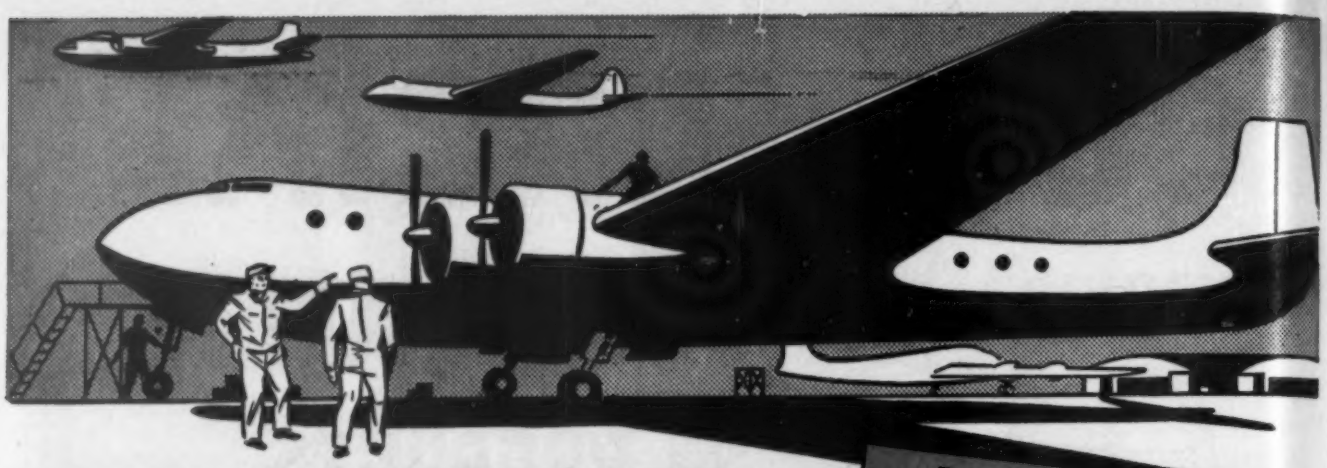


AVIATION HYDRAULICS

DESIGN
OPERATION
MAINTENANCE

FRED O. HOSTERMAN
Advisory Editor

Reduction of Hydraulic Noise and Vibration

PART I

By G. W. LOUTHAN
Mechanical Research Group Engineer
Lockheed Aircraft Corporation
Burbank, California

HYDRAULIC NOISE IN AIRCRAFT has passed beyond the stage of being a mere nuisance. Increases in operating pressure and a steady growth in circuit complexity have led to the incidence of more serious effects. It is not sufficient to reduce the hydraulic noise audible in the cabin, though this matter deserves all the attention it has received in point of improved system mounting, practical isolation of local sources and the like. A more fundamental trouble arises from the excessively high rates of pressure change, of which the noise is the outward token. Such high rates involve correspondingly high forces, however localized, and there can be little doubt but that these forces play a distinct part in the service deterioration of aircraft hydraulic pumps and motors, which are the chief source of repetitious high pressure rates. A more subtle but a dangerous effect may lie in circuit response to the intense and sustained vibrations within the hydraulic fluid. Various seals or packings and the joints between tubing are especially vulnerable in this respect. It is not only possible but distinctly probable that the pressure amplitude generated at pump or motor will be amplified more or less in some branch or part of the circuit having receptive proportions. The type of damage ensuing may be cavitation erosion, leakage erosion or cracking from repeated though transient overstress.

To summarize, the nominally D.C. aircraft hydraulic systems have superimposed upon them a certain degree of A.C. behavior, for which no design allowance is made, ordinarily.

This article is condensed from a Lockheed report of the research work done from 1944 to 1948 by A. M. Kellam and his associates and originally reported by A. M. Kellam.

Statement of Basic Problem

Hydraulic pumps and motors function by transferring discrete parcels of fluid from one pressure state to another. The elasticity, such as it is, of the liquid is not used for the performance or reception of work. So far from being used, the potential energy of the liquid in one state with respect to the other state is the very source of the disturbances being considered. The physical process is always one of filling a cylinder at one pressure, connecting it to another region at a different pressure and then discharging the cylinder. In a pump, this means that a cylinderful of oil at a low pressure is more or less abruptly connected to a system of oil at high pressure. In the fleeting process of pressure equalization, oil surges into the cylinder from the system, thereby propagating a

reduced-pressure wave throughout the system, followed at once by a positive pulse as the local fluid motion is checked and reversed by elasticity. For a motor, the same general thing occurs, with the sign reversed for pressure pulses. At the inlet port a similar occurrence takes place but on a much reduced scale, since there the minimum (clearance) volume of oil is involved.

The fundamental problem is to eliminate or at least to reduce greatly the disturbances at their source. As a practical alternative, the isolation of pulses from the system must be considered in detail.

Details Regarding Wave Origin, Pressure Discontinuities

Let:

P_n = Pump inlet pressure, psia
P_d = pump discharge pressure, psia
V_c = swept volume of each cylinder, cu in
V_o = clearance volume of each cylinder, cu in
and K' = adiabatic bulk modulus of liquid elasticity, psi

For the present purpose, it is sufficient to examine the potential energy changes incurred by one cylinderful of liquid in passing through the pump; kinetic and friction quantities are irrelevant here.

In passing from inlet to discharge, the change in liquid volume is:

$$V_n^d = \frac{(P_d - P_n)}{(K' \quad K')} \cdot (V_c + V_o) = \frac{(P_d - P_n)\ (V_c + V_o)}{K'}$$

Assuming no material change in the value of (K') during the transfer, the parcel of liquid is a fluid spring, taken from an initial to a final state of strain. The change in potential energy equals the work done between initial and final states. As with any elastically strained system, this work is the product of displacement and mean force during displacement, so in this case, with constant spring rate,

$$(P.E.)_n^d = \frac{(P_d - P_n)\ (V_c + V_o)}{K'} \cdot \frac{P_d + P_n}{2} = (P_d^2 - P_n^2) \cdot \frac{(V_c + V_o)}{(2K')} \quad \text{.....(1)}$$

While for the return of that cylinder from discharge to inlet conditions,

$$(P.E.)_d^n = (P_d^2 - P_n^2) \cdot \frac{V_o}{2K} \quad \text{.....(2)}$$

These quantities are distinct from the mechanical work involved in promoting flow at discharge pressure; that is, normal pump work. Rather do they represent a work residue, positive or negative, which is stored elastically in the fluid incidentally to its change in pressure. In the great majority of pumps and in all motors used in aircraft hydraulics, these elastic changes in the fluid occur outside of pump or motor, as the design of such units does not allow expansive use of the fluid. Thus it is that hydraulic noise originates at pump or motor ports and the wave energy is drawn solely from the elastic strain of the fluid. Furthermore, as equations (1) and (2) indicate, the available wave energy is proportional to the difference of squares of the absolute pressures existing at opposite ports. Since actual wave energy is also proportional to the square of the pressure amplitude, the implication is that the pressure amplitude of port waves from pumps varies nearly directly with discharge pressure, because aircraft pump inlet pressure is low, both absolutely and in relation to discharge pressure.

The foregoing is a greatly simplified statement of the case, in that it is premised upon a homogeneous liquid, zero leakage across ports and an instantaneous discharge. None of these conditions exist in actual service, but the simple theory checks fairly well with experiments and so is of some use as an introductory concept. The main disparities between the effects of such an idealized noise source and those of a real one are:

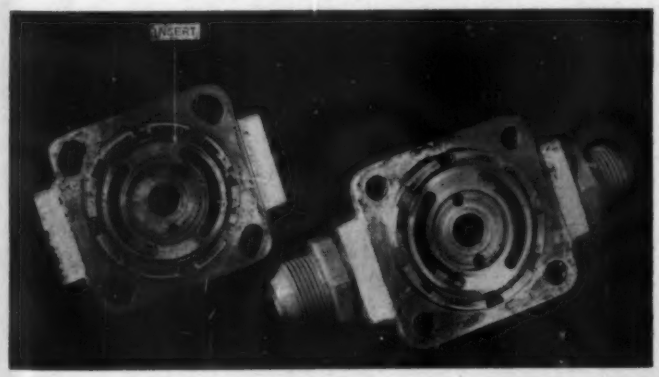


Fig. 1. Reworked (left) and standard Vickers pump valve plates. The interport seal length on the entering end of the discharge port has been increased for the compression lap tests.

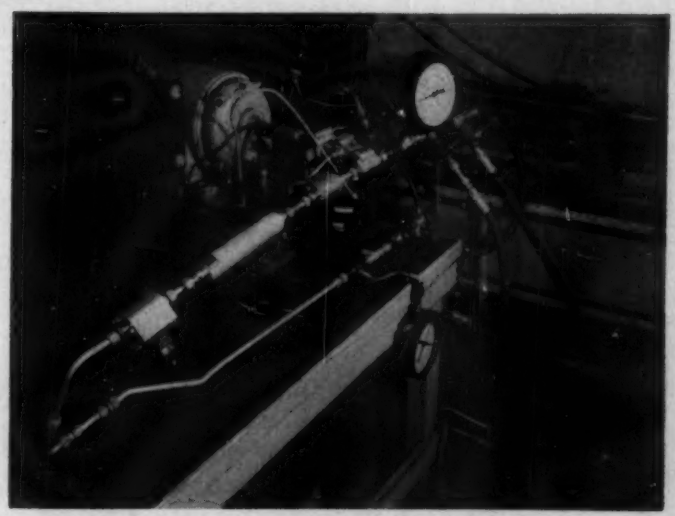


Fig .2. Apparatus set up for basic pumping tests. A pulsation filter is shown between the strain gage units.

a. Actual wave amplitude does not rise as rapidly, with increasing discharge pressure, as has been suggested. This is due partly to leakage, partly to the rapid rise of internal damping, both in fluid and tubing, and partly to the real wave form, later discussed.

b. Actual wave amplitudes may be considerably higher, under any service condition, than the simple theory values. This is due to the presence, in the fluid, of appreciable amounts of free air, which profoundly affects wave generation. The allusion here is not to gross and obvious cavitation, but rather to a condition of the oil which no feasible amount of supply tank pressurization can prevent.

What follows refers particularly to piston type pumps and motors, but applies to any other make using either a swashplate or a Janney linkage to drive the pistons. A geometric analysis of these devices will show that in general there need be no variation, with time, of the total oil volume above pistons considering the pump as a *whole*, but each side of the pump (inlet and discharge) does undergo a variation in displacement rate. In the case of a 7-cylinder unit, for example, each port connects to 3 and 4 cylinders alternately and the related motions of the various pistons are such that flow into or from a port will undergo 14 maxima and 14 minima for each complete revolution of the pump shaft. Furthermore, the difference between maximum and minimum combined flow rates will be about 2.5 percent of the average discharge rate of the whole pump or motor. Thus there exists an innate displacement ripple of appreciable magnitude and of (2Nn/60) frequency, for an (n)-cylinder pump running at (N) rpm. With any inertance (line length) connected to either port, an audible hum results. For all ordinary circuit arrangements in aircraft, the pressure amplitude for flow ripple is much smaller than the port pressure pulses. For pumps, the two kinds of pressure waves are only 90 degrees out of phase and so are in some measure additive.

Fig. 3. Curves Sheet One, shows the plot of the oscilloscope trace against pump discharge pressure for a uniform inlet pressure of 25 psig. The center isometric curves, connected by discharge isobars, indicates that noise reduction is still being gained at 1400 psig; the rear curve shows the effect of moving the vale plate 3.5 degrees in the direction of pump rotation; the front curve shows performance obtained by rotating the valve plate 3.5 degrees against rotation.

The Rationale of Pump Alterations

The flow ripple is due to the use of a finite number of displacement elements, hence it cannot be eliminated. However, since it is the less important of the two basic sources of noise, more interest attaches to the reduction of port pulses. There are only two ways of doing this and they are:

(a) Reduction of pressure change experienced by the fluid in leaving or entering the cylinder.

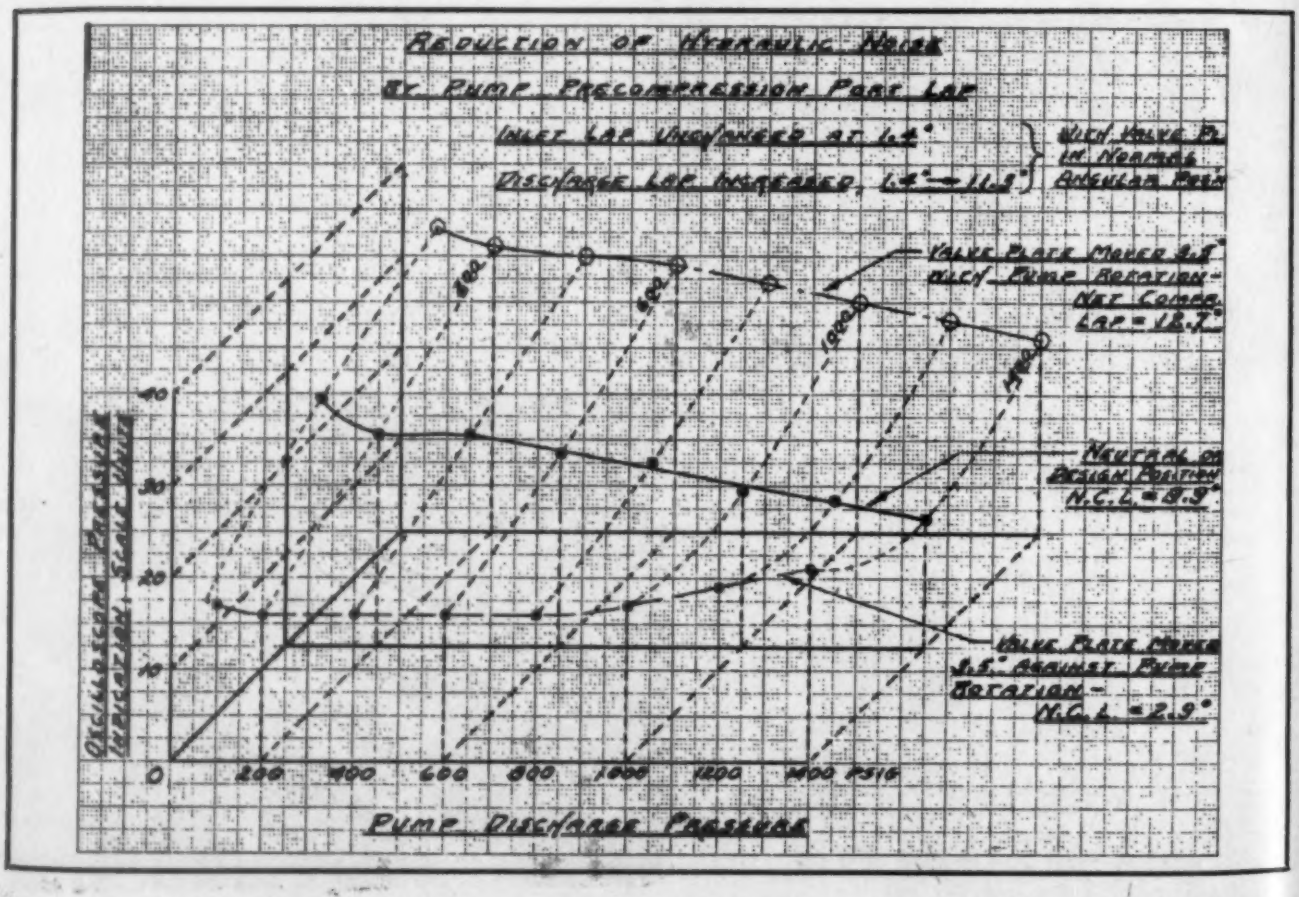
(b) Increase of time for pressure changes to occur.

Since it can be shown that an increase in time results in an appreciable increase in pump leakage, manipulation of cylinder pressure gives a much better approach to the problem in at least two practical respects:

(1) Pump leakage is reduced, not deliberately increased.

(2) The pump alteration is much easier to calculate and to make.

(Continued on page 28)



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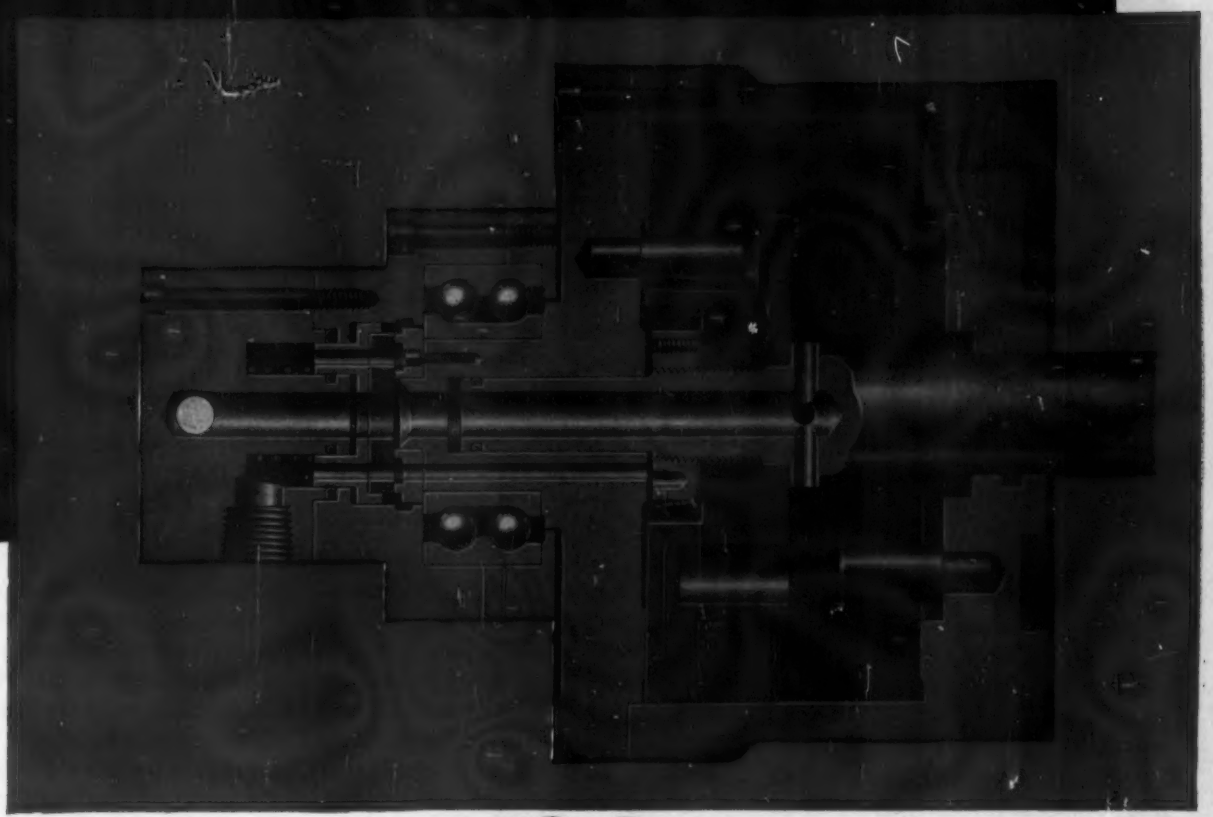

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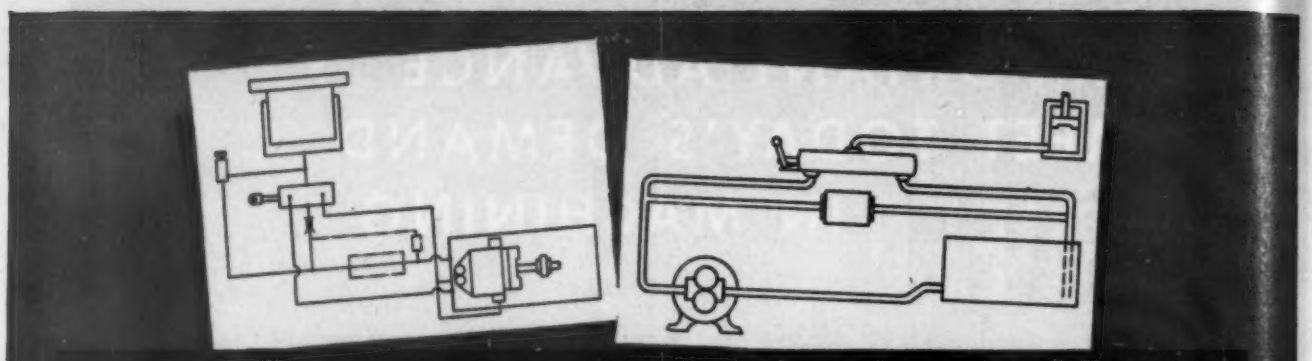

A Beginner's Course in Basic Hydraulics

CHAPTER IV

GASKETS, OIL SEALS AND PACKING RINGS; MAINTENANCE OF HYDRAULIC EQUIPMENT

Part 3

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Gaskets, Oil Seals and Packing Rings

Gaskets made of relatively soft materials are placed between the meeting surfaces of hydraulic fittings in order to increase the tightness of the seal. They should be composed of materials that will not be affected by the liquid to be enclosed, nor by the conditions under which the system operates, including maximum pressure and temperature. They should be able to maintain the amount of clearance required between meeting surfaces.

The selection of correct seals and their proper installation is an important factor in maintaining an efficient hydraulic system. Commercial manufacturers specify the kinds of gaskets to be used on their equipment; their instructions are to be followed in replacing gaskets. If the proper gasket is not available, careful consideration should be given to the selection of a suitable substitute.

Neoprene gaskets. One of the most widely used materials used in making gaskets for industrial hydraulic systems is neoprene, a synthetic rubber and fibre composition which comes in sheet form to be used between flat surfaces and in molded packing rings to be used around movable rods and shafts. Since neoprene is flexible, it is often used in sheet form at points where a gasket must expand enough to allow air to accumulate, as for example, with cover plates.

Over a period of time oil tends to deteriorate the material used in making neoprene gaskets. For this or mechanical reasons, small particles of the material may be cast free into the system and may plug small orifices and restricted passages. The condition of the gasket must therefore be checked whenever the unit is disassembled.

Since neoprene gasket material is soft and flexible, it easily becomes mis-shapen, scratched or torn. Great care is therefore necessary in handling. Shellac, gasket sealing compounds or "pipe dope" should never be used with sheet neoprene, unless absolutely necessary for satisfactory installation.

Oil-treated paper. This widely used gasket material is manufactured by a number of companies under various trade names, e.g., Gaskoid, vellumoid and consolco. Gasket paper usually comes in sheets and the repairman must cut the gasket for each particular installation. The paper should be marked to size and cut with a sharp knife or snips. It should not be placed on the valve plate or other surface and tapped with a ball peen hammer to make the desired passages, since this will cause burrs.

Sheets of gasket paper vary in thickness from several thousandths of an inch to almost any desired thickness. A thick gasket is not always the best. Where the gasket is to be installed between a valve plate and the valve block, for example, the thickness of the gasket may determine the clearance of working parts.

When oil treated paper gaskets are torn, wrinkled or bent, leaky connections may result. If gasket shellac or cement is used, it should be applied to one side only so that the gasket will not be torn when disassembly is attempted.

Lead foil. In some high pressure connections with only slight clearance — usually from .001 to .005 inch — lead foil is used as gasket material. It is soft and pliable, so that it easily fits an uneven contour. When disassembling a unit where lead foil gaskets have been used, great care is necessary not to bend or tear the foil if it is to be used again.

Cork. This material makes a good oil seal and can be used under various pressure conditions. Cork is in fact one of the best gasket materials available. It is very compressible and can be cut to any desired thick-

ness to fit any surface, and yet can be made to give a desired clearance while forming an excellent oil seal.

Cork requires the same care in disassembly as any other soft gasket material. The condition of cork gaskets should be checked for defects when a unit is disassembled, so that small particles will not be cast off into the system during use.

Copper. This material, when permissible, is used in the form of flat copper rings under adjusting screws, etc., to give oil seals and as molded copper rings to be used with speed gears, etc., operating under high pressures. Either type is easily bent and requires careful handling. In addition, copper becomes hard when used over long periods or if subjected to compression. Whenever a unit is disassembled, the copper gasket rings should be softened by annealing.

Neoprene packing rings for moving parts. The neoprene used for chevron packing rings is made of a harder composition than that used for gaskets, and is molded to fit a particular stuffing box and rod. This type of ring is sometimes filled with soft neoprene strips. Under pressure the chevron packing rings are forced together so that they spread out, at the same time causing the soft filler to expand and thus force the feathered chevron edges more firmly against the rod. Figure 64 shows a number of chevron packing rings in place around a piston rod.

Before installing this type of ring, it should be soaked in oil for several hours to help it assume the shape of the rod. If it is not possible to soak the packing, the tightening nut should not be tightened enough to bind the rings or cause them to become misshapen.

Until the packing becomes set, the leakage around the shaft may seem excessive. Since a small amount of leakage is unavoidable, and is necessary for lubrication of the rings and shaft, the tightening of the retaining element is an operation requiring great care.

When disassembling a hydraulic unit where this type of packing ring must be removed over a threaded shaft pr rod, the threads should be covered with a thin piece of sheet brass or a cap usually provided for this purpose, in order that the the threads will not damage the interior of the packing ring.

Steel sealing sleeves. A sleeve joint or coupling is sometimes used to connect lengths of pipe in a high pressure line. It consists of a short steel cylinder, from .10 to .15 inch larger in diameter than the pieces to be joined. The sleeve is fitted over one of the pipe ends, the other pipe end is introduced, and the two ends carefully aligned (Figure 65). The two ends of the sleeve are set in place and flange-held, or they may be welded to the pipe. The connection must be drawn up evenly, since a sleeve out of alignment will almost invariably leak.

Maintenance of Hydraulic Equipment

General requirements. In the installation of various pipes, tubes and fittings of a hydraulic system, it is necessary that they be *absolutely clean, free from scale and from all kinds of foreign matter.* The general requirements for and procedures to insure cleanliness are as follows:

(1) All pipe, tubes and fittings must be absolutely clean and free from scale and all foreign matter.
(2) All pipe, tubing and fittings on which work has been done shall be cleaned in the manner to be described and protected after all work operations are completed.
(3) All interior surfaces shall be treated to prevent rust or corrosion and all openings shall be sealed or plugged to exclude foreign matter during shipment and storage prior to installation.
(4) All pipe, tubing and fittings shall be recleaned and repickled whenever heat is applied for the purpose of bending, annealing or performing other operations after removal of the original scale.
(5) All pipe, tubing and fittings shall be thoroughly cleaned just prior to installation.

Safety precautions. Dangerous chemicals are used in the operations to be described. They should be kept only in the proper, approved containers and *handled with extreme care.* Many acids give off dangerous fumes when brought into contact with air and can injure clothing or human tissue even when in the gaseous state. Contact with these chemicals or their fumes should be avoided. The use of rubber gloves and aprons is advisable; special acid goggles should be worn if extended operations with acids are necessary.

Hydrofluoric acid must be kept in lead, paraffin or rubber containers, since it very quickly decomposes

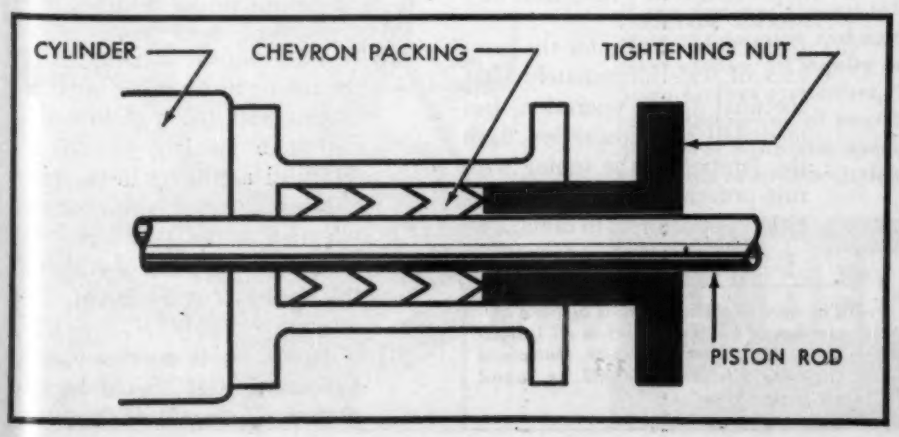

Fig. 64. A typical installation of chevron packing rings in place around a piston rod.

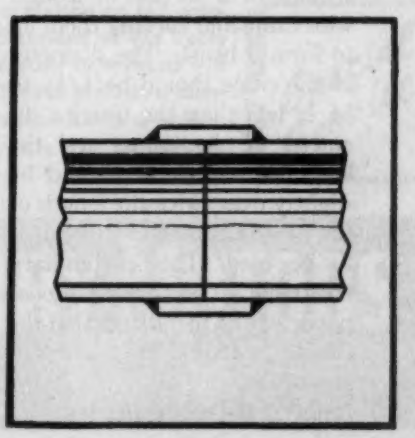

Fig. 65. A sealing sleeve on the ends of pipe in a high pressure line may be welded, as shown, or flange held. The ends must be carefully aligned and the connection drawn up evenly to avoid leakage.

glass. In mixing acids with water, especially in the case of sulphuric acid, the acid should be slowly added to the water, and not the opposite, or a violent explosion may result. The point is to begin with a very dilute solution and gradually increase its strength.

An alkali like lye is also capable of injuring clothing and tissue if present in sufficient concentration. The best procedure, of course, is to avoid direct contact. None of these chemicals should be taken internally under any circumstances. If contact with any of them should occur, and the resulting wound is anything but trivial, medical aid should be summoned at once, the affected parts should be liberally doused with cold water and steps should be taken to neutralize the chemical action. This means that acids should be treated with *dilute* solutions of *weak* alkalis, and alkalis with *dilute* solutions of *weak* acids. A very dilute solution of ammonia can be applied to an acid burn; vinegar, which is a dilution of acetic acid, can be further diluted and applied to alkali wounds. These treatments are not advisable if the eyes have been affected, except for the dousing with water. A boric acid solution, however, can be applied to the eyes. After treatment the wounds can be covered with an oil dressing.

Procedure for iron and steel. The following procedure is recommended for the pickling and cleaning of iron or steel pipes, tubes and fittings:

1. **Preparation for pickling to remove scale:**

(a) Grind out spatter from welding or brazing operations.

(b) Brush with a boiler tube brush. If this is not available for small tubing, use a brush improvised by cutting the out strands of a section of a steel wire cable and turning them up to form a brush. The diameter of the cable should be 1/16 to 1/8 in less than the interior diameter of the tubing and the length of the cable should be slightly over twice the length of the longest tubing in which it is to be used. This preliminary treatment serves to remove loose particles and to indicate that the tubing is free from major obstructions.

(c) Immerse the tubing in a lye solution (6 oz per gal) at a temperature of 160-180 F for four hours to remove oil or grease previous to pickling.

(d) Rinse with hot water to remove the lye solution.

2. **The pickling operation:**

(a) Pickle to remove scale in a hot solution (110-140 F) of the following solution:
Commercial sulphurs acid (Sp Gr 1.84), .5 pint by volume (14.3 oz by weight); Commercial hydrofluoric acid (30 percent), .4 pint by volume (7.4 oz by weight); Commercial inhibitor (.067-.134 oz by weight); and water 7.1 pints by volume to give one gallon of solution.

The time of pickling will be determined by the amount and depth of scale on the interior surfaces of the tubing. The position of the tubing during pickling should be changed occasionally to make sure that if gas pockets form, they will not always occur at the same location.

3. **Treatment after pickling:**

(a) After the scale has been removed, rinse the tubing first with hot water, then with cold water. Immerse the tubing in a solution of lye (6 oz per gal) from 5 to 10 minutes to remove all traces of acid.

(b) Rinse free from the lye solution with hot water and immerse the tubing in a solution containing 4 oz per gal of sodium cyanide for 2 hours. Rinse thoroughly with hot water. Blow out with dry air until the surfaces are dry.

(c) Use wire brush. Blow out with dry air under high pressure.

Do not use rags or waste in any of the drying operations since lint or thread may be retained in the tubing.

4. **Inspection and Protection of interior surfaces:**

(a) Inspect the tubing for the presence of scale immediately after the final drying operation. Immediately after inspection, flush the interior of the tubing with rust preventive compound (52-C-18) and allow it to drain. The coating of light oil serves as a temporary protection against corrosion during the interval (normally 1 to 3 days) between the pickling operation and the hydrostatic tests. After oiling, plug both ends of the tubing to exclude foreign matter and remove from the plating shop or department as soon as possible to avoid attack from fumes.

5. **Treatment during hydrostatic tests:**

(a) Remove the rust preventive compound on the interior surfaces of the tubing by dissolving in Stoddard solvent (Federal Specification P-S-661) previous to the hydrostatic tests.

(b) All water used in the hydrostatic tests must contain 0.66 oz of neutral CP sodium chromate to a gallon of water. The presence of the sodium chromate in the water retards the formation of rust. After the hydrostatic tests have been made, drain the solution from the tubing and blow out with dry air until the interior surfaces are dry.

(c) After the interior surfaces are dry, apply rust preventive compound (52-C-18) and rub in thoroughly with a wire brush.

The application of the rust preventive compound provides a protection against corrosion of the interior surfaces of the tubing during storage and shipment. After the rust preventive compound has been applied, plug both ends of the tubing with wooden plugs to exclude foreign matter during storage and shipment. The rust preventive compound should not be removed until just before installation. A preparation known as Stoddard solvent may be used to remove the rust preventive compound.

6. **Conditions under which repickling is necessary:**

(a) If a subsequent installation of the tubing involves the application of heat (such as in bending) the tubing should be repickled according to the procedures described, since the application of heat is likely to cause the formation of scale on the interior surfaces of the tubing.

(b) If repickling is necessary, the hydrostatic test should be repeated.

The next installment will begin a discussion of valves. Preserve all installments for future reference. Questions covering Chapter IV will be found on page 42.

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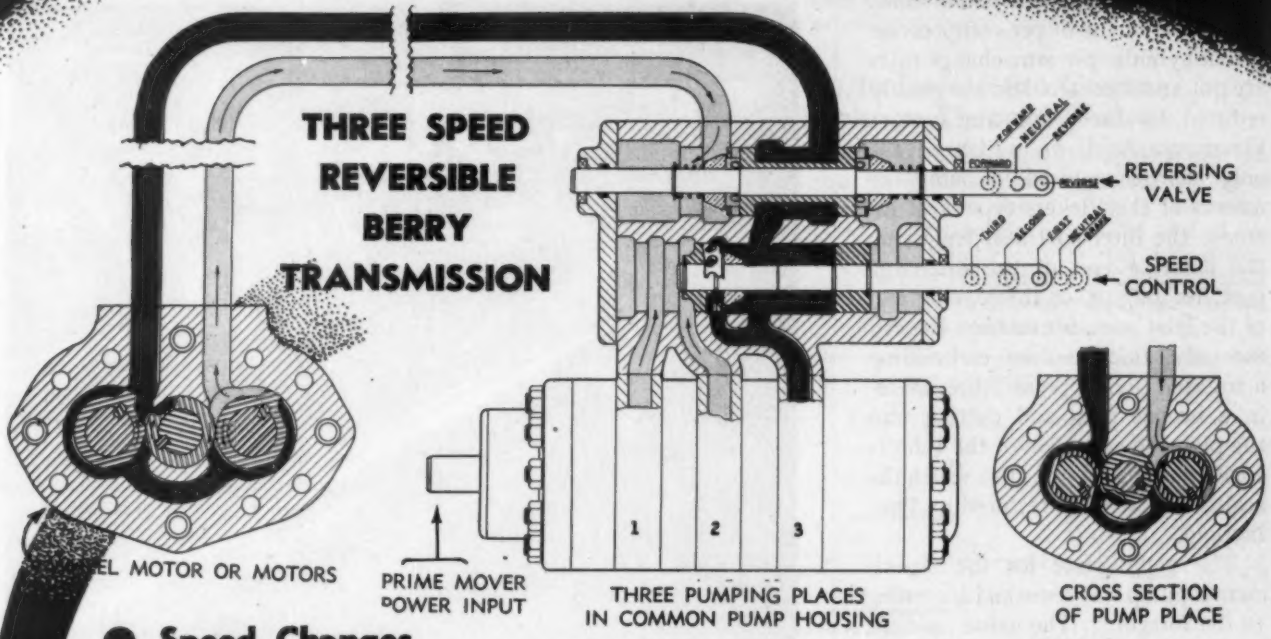

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HYDRAULIC NOISE

(Continued from page 22)

The essence of this method for abating pump noise lies in pre-compression of the fluid before exposing it to discharge. The discharge lap of the valve system is increased enough to apply such pressure and to perform the requisite elasticity work on the fluid. This is not extra work, but merely anticipated work. The prime virtue of pre-compression is that cylinder pressure change rates are put under control and are greatly reduced by the pump (or motor) kinematics. As shown in Figure 1, the only change required in pumps or motors of the Vickers type is to increase the inter-port seal length on the entering end of the discharge port, for pumps, or the leaving end of the inlet port, for motors. Experimentally, this involved end-milling a suitable cavity, press-fitting therein a bronze plug and cutting into the plug the extension of the (shortened) discharge port, after which the sealing surface was restored by light lapping.

The valve plate for the experimental pump was reworked according to the foregoing. The value used for (K′) was that derived from the acoustic velocity tests, 180,000 psi, and so represents nominally bubble-free (pressurized) oil. The tests of pre-compression benefit gave a direct comparison of port pulse intensity by using alternately a standard valve plate and the reworked one, on the same pump. Stud holes in the reworked plate were elongated to give about ±3.5 degrees angular adjustment, to add to or subtract from the plate's 11.3 degrees value. Even with an inlet pressure of 0 psig, giving mild cavitation, the value of pre-compression was indicated distinctly, while application of a representative inlet pressure of 25 psig gave the anticipated improvement. Figure 3, Curve Sheet One, summarizes the tests on the revised pump. The height of the oscilloscope trace, which is a linear function of port pulse pressure amplitude, is plotted against pump discharge pressure for a uniform inlet pressure of 25 psig. The isometric array of curves, connected by discharge isobars, is believed to give an adequate conception of the pump's behavior in these experiments and comment on the curves is restricted to these points:

(a) The *net* compression lap in the test pump was 9.9 degrees, corresponding to minimum noise at about 1550 psi port pressure difference or 1575 psig discharge pressure. The middle one of these three curves shows that noise reduction was still being gained at 1400 psig, with the reworked valve plate and pump body in their normal relative angular position.

(b) The foremost curve of the three shows the performance obtained by rotating the valve plate the full 3.5 degrees against rotation. All events thus occurred earlier; the admission lap increased from 1.4 degrees to 4.9 degrees and the gross discharge lap was correspondingly reduced from 11.3 degrees to 7.8 degrees, giving a net compression lap of (7.8 — 4.9) degrees or 2.9 degrees. The calculated discharge pressure to match this new condition is 480 psig, which is seen to be entirely consistent with the shape of the curve under discussion. It is worth note, however, that in this latter case about 15 percent greater amplitude of port noise was indicated, as compared with even the non-minimum condition of 1400 psig and neutral adjustment. The explanation is considered to be that with admission lap as great as 4.9 degrees, appreciable forced cavitation occurred inside the charged cylinder as it crossed back center. This may well have disturbed the air content of the oil enough to give some air knock at discharge, since the degassing of a liquid by a pressure reduction is more rapid than the reversed process.

(c) The rearmost curve on this sheet shows the effect of moving the valve plate 3.5 degrees from neutral in the direction of pump rotation. The calculated dis-

(Continued on page 30)

Superdooper Hydraulic Cylinders

THE LOGANSPORT MACHINE COMPANY, manufacturers of air and hydraulic equipment for industrial use, reports the completion of production work on two huge hydraulic cylinders believed to be the largest of their type ever built. The cylinders were built for the Listerhill, Alabama, plant of the Reynolds Metals Company and were ordered for use in new casting machines for casting a heavier billet.

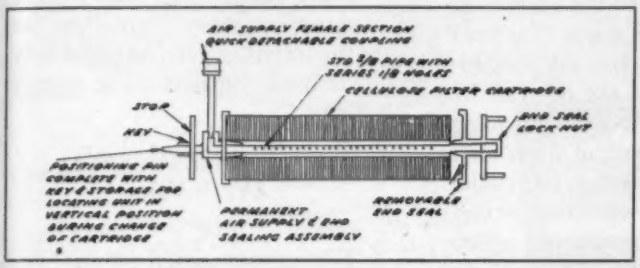
The great cylinders have a bore of 14 inches and a stroke of 237 inches. The 5 inch diameter stainless steel piston rod weighs 1600 pounds; the tube is of centrifugal cast steel. The total weight of cylinder and piston is 3½ tons. The overall length of equipment with piston rod extended is approximately 500 inches.

HERE'S HOW

- PREVENTIVE MAINTENANCE
- SERVICE PROCEDURES
- MODERNIZATION
- SHORT CUTS

Cleaning Cellulose Type Oil Filter Cartridges

A RECENT investigation in our department on the replacement cycles for cellulose type oil filter cartridges indicated that considerable savings were possible by providing for a cleaning program to rehabilitate the dirty cartridges when necessary rather than replace them with new cartridges. On some of the larger filter units as many as 62 individual cartridges would be involved per filter.


AIR SUPPLY FEMALE SECTION QUICK DETACHABLE COUPLING
STD 3/8 PIPE WITH SERIES 1/8 HOLES
CELLULOSE FILTER CARTRIDGE
STUD
KEY
END SEAL LOCK NUT
POSITIONING PIN CONNECTED WITH KEY & STORAGE FOR LOCATING UNIT IN VERTICAL POSITION DURING CHANGE OF CARTRIDGE
PERMANENT AIR SUPPLY & END SEALING ASSEMBLY
REMOVABLE END SEAL

After experimenting with several methods of cleaning, it was found that a very satisfactory cleaning job could be obtained by simply immersing the dirty cartridges in a solvent bath and blowing air through the cartridge body from the inside. The violent action of the solvent caused by the air stream tends to scrub off the dirt which is carried to the outer surface of the cartridge body by the air passing through the cartridge. For all practical purposes the cleaned cartridge has proven to be equal to the new cartridge.

The actual procedure determined upon and now standard with our maintenance crews can be followed by reference to the diagram.

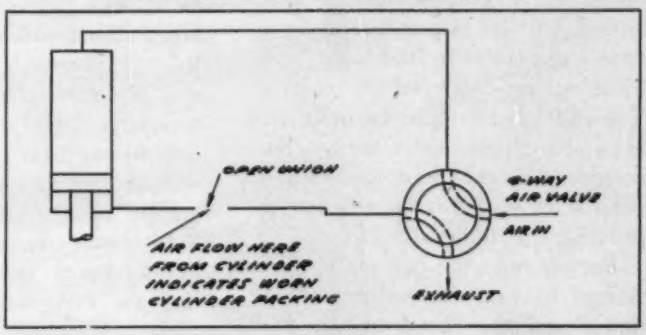
The dirty filter cartridge is slipped over the air blast line and the end seal is secured by threading the lock nut. The entire assembly is then immersed in a bath of solvent, such as Stoddard solvent, and the air supply is turned on, causing a severe agitation of the bath. The scrubbing action of the solvent in the agitated state is an effective means of removing the solids from the cartridge body. The time cycle required in the cleaning operation can be minimized by a pre-soak in the solvent and the use of wetting agents in the solvent itself.

Before and after removing the assembly from the solvent, the cartridge is mounted in the upright position by inserting pin and key through the hole provided in the false bottom of the drip pin. This procedure eliminates the possibility of damage to the cartridge element.

C.E.P.

How to Isolate the Cause of Leakage Through Valves

IN OUR WORK, particularly in pneumatic applications, we have found that many maintenance personnel are unfamiliar with a simple procedure for isolating the cause for continuous emission of air through the exhaust port of the four-way valve when the cylinder is at the end of its stroke. Such a condition is usually charged to a faulty valve; as a matter of fact, in most cases, it is merely an indication that the cylinder cup leathers are becoming worn.



The proper procedure is to extend the cylinder to either its top or bottom maximum stroke and open a union or fitting in the exhaust side. If air continues to be emitted at the point where the line is opened and is from the direction of the cylinder, it is an indication that the leakage is past the cylinder packing and not a by-passing within the valve.

The same test can, of course, be applied to a hydraulic system which appears to be slowing down through excessive leakage. Similarly, the leakage could be either at the valve or in the cylinder and the same procedure will isolate the cause of the leakage.

J.M.G.

Readers are invited to contribute their short cost and labor saving shop or plant ideas. Each contribution will be acknowledged and considered for publication. We will pay $5.00 for each item published. —Here's How Editor

NEW J.I.C. STANDARDS

(Continued from page 18)

ment" are marked as engineering developments as defined above. The supplemental, unnumbered sections on steel tubing (sizes and wall thicknesses for various pressures), seamless low carbon steel tubing (specifications, including hydrostatic test, physical properties and allowable variations) and the paragraph on pressure regulators and relief valve springs for hydraulic systems (unchanged from previous issue) have also been marked as engineering developments. Paragraphs in the seamless low carbon steel tubing section relating to length of tubing furnished, marking identification, packing requirements, information to be shown on bundles or boxes and terms of rejection, shown in the previous issue, have been dropped from the new issue.

The changes in the new issue of the Standards are, for the most part, relatively minor and in the direction of clarification and ease of compliance and represent a normal development in the Standards as their acceptance increases throughout the industry.

Individual copies, or a reasonable number of additional copies, of the J.I.C. Hydraulic Standards for Industrial Equipment, September, 1949, issue may be obtained by contacting Mr. J. C. Rauss, Production Engineering Section, 15-228 General Motors Bldg., Detroit 2, Mich. Complete reproduction of the Standards is permissible.

PUMPS AND FLUID MOTORS

(Continued from page 13)

Pump Controls

Another design feature of this type of variable volume pump is the positioning of the cam plate. The cam plate is pivoted on a line running through the point where the forces which would tend to unbalance the cam plate converge. This permits easy shifting of the cam plate when the pump is operating under maximum volume and maximum pressure. The improved control of both volume and pressure has many advantages on fluid motor applications where either torque or speed must be varied.

Since fluid motors are responsive to both the pressure and volume of the hydraulic fluid, it follows that a pump whose output can be easily varied, both as to pressure and volume, can control a fluid motor with little or no intermediate valving. The controls that can be built into axial piston pumps give the machine designer a wide latitude of available volume and pressure, as well as simplifying the hydraulic circuit.

For example, the cam plate can be shifted to vary the volume of the pump and the speed of the fluid motor by turning a handwheel on the pump. The handwheel may be replaced by a simple stem control, which may be connected by mechanical linkage to a remote operating position where very little force is required to vary the pump. Hydraulic servo control provides much the same operation.

On winding or feeding operations, where constant speed under varying loads or where constant torque under varying speeds is required or where constant tension must be maintained, pressure responsive controls can be furnished which will cause the fluid motor to accomplish the desired result automatically.

Circuits and Valving

The application of the fluid motor will largely determine the selection of the pumping unit and the development of the hydraulic circuit. Circuits, generally, are single directional or reversing and either constant or variable speed. Where fluid motors are to be stopped and started repeatedly, consideration should be given to the acceleration and deceleration time desired and whether or not the fluid motor is to reverse rapidly under a high inertia load. These factors will effect the circuit as well as the piping and the valves selected. Proper flow velocities must be maintained and ample pipe size is imperative. Many pump installations are impaired by restricted suction lines and frequently pump and fluid motor operation is made erratic by the failure to run drain lines directly back to the tank. In operations where several fluid motors are run from one power source, care should be taken to control the flow of oil to the individual fluid motors in such a way that load variation of one motor will not upset the operation of the others.

It is hoped that the foregoing comments will be helpful when used as a basis for analyzing individual applications with a view to selecting those hydraulic components which will best serve the purpose and perform the operations required. It is safe to say that modern high pressure pumps and fluid motors have opened up an entirely new field of fluid power transmission and new developments now in process will increase even further the adaptability of this type of equipment.

PRODUCTION CALIBRATION

(Continued from page 15)

Two methods may be used in reverse-calibration of instruments from maximum pressure across the scale to 0 pressure. Pressure may be metered into the rod end of the air cylinder to counter-act pressure at the air cylinder to counter-act pressure at the blind end; or the bleed-off through valve No. 12 may be increased at the same time gradually closing metering valve No. 10. Either is equally satisfactory.

The first intensifier used provided a usable displacement of approximately 7.8 cubic inches of fluid, permitting a considerable loss of fluid before a recharging of fluid lines was necessary. The recharging itself required so little time that subsequent units have been furnished with air cylinders of lesser bore and stroke and with piston rod plungers of smaller diameters, conserving space and effecting further economy.

HYDRAULIC NOISE

(Continued from page 28)

charge pressure to suit this is 2685 psig, so considerable noise occurred at the lower discharge pressures, with reversal of the usual pressure pulses.

(d) Offhand, it might be supposed that compression lap would be distinctly beneficial at only one pressure. The slope of the middle curve, however, reflects the general observation made during the experiments: that noise intensity changes were more gradual, with respect to discharge pressure trends, for the reworked valve plate than for the standard part. As previously derived, the port pulse energy is:

$$(\text{P.E.}) = E = (P_d^2 - P_n^2) \cdot \frac{(V_c + V_o)}{(2K')}$$

For an unmodified pump, (P_n) is the inlet pressure or very nearly such. Therefore, low values of (E) can occur only at low values of (P_d), the discharge pressure. But for a pump with compression lap, (P_n) is the cylinder pressure at discharge and on either side of the optimum condition ($P_d = P_n$) there exists an appreciable range of discharge pressure wherein (E) does not increase rapidly. In other words, the optimum lies in a wide valley, within which it is entirely feasible to contain the majority of the pump's operating pressure conditions.

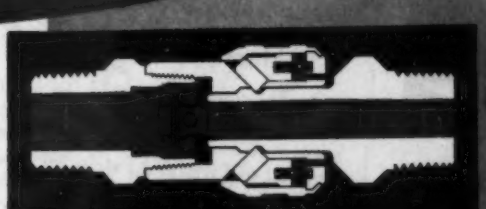
Thus far, this article has been confined to discussion of a means of eliminating hydraulic noise at its chief source, the pump. No particular mention has been made of the effects of cavitation or of air entrainment in the oil. These effects were evaluated in the test program but the results have not been included here due to lack of space and also because it is generally acknowledged that both cavitation and air entrainment will cause an increase in discharge pressure variation and system noise.

Part II of this article will deal primarily with a study of devices designed to reduce the transmission of pump noise into the remainder of the hydraulic system.

SAVE ✔TIME ✔TROUBLE ✔MONEY WITH THESE HANSEN COUPLINGS

HANSEN PUSH-TITE COUPLING
Shuts off one side of line

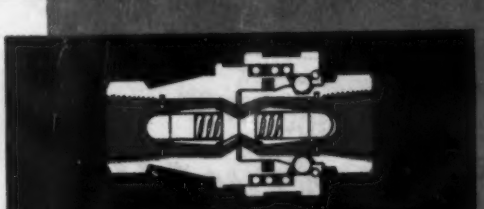
Gives quick connection and disconnection, with instant automatic flow or shut-off. To connect coupling, and open line to flow of fluid, merely push plug into socket. To disconnect, a slight pull on sleeve releases plug and shuts off supply end of line.



PUSH-TITE COUPLING

HANSEN HIGH PRESSURE TWO-WAY SHUT-OFF COUPLING

To connect, pull back sleeve and push plug into socket. Identical torpedo type valves permit free flow of gas or liquid through coupling. To disconnect, pull back sleeve . . . coupling immediately disconnects, valves automatically seal both ends of line. Can be mounted to disconnect automatically where fluid lines may be subject to sudden, damaging strain.



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Provides quick connection and disconnection, but does not have shut-off feature. Size range for general use from ¼" to 2½". Two special types of straight-through steam couplings also available—one for low pressures, and one for high pressures.

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New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

"Push Button" Control Air Valve

A new, fast cycling, hand operated valve which provides four-way directional air control for the operation of single or double acting pneumatic cylinders and other air operated equipment is announced by Hannifin Corporation. A light pressure by fingers, palm or knee to depress the control knob 3/8 in is all the motion required to operate the valve. Air line pressure, acting through a pilot control, supplies the force to move the piston operated main valve. Model NHS is ruggedly constructed for heavy duty industrial service and is available in ½ and ¾ in sizes for use with line pressures of 25 to 150 psi. The valve can be mounted in any position that keeps the valve operating piston in a horizontal plane. *1.*

Aluminum Air Cleaner

An air cleaner designed for a number of applications including air compressors and small engines is the newest product of Pittsfield Products, Inc. Copper crimp is used as a filter medium to provide an efficient dust retaining area when dipped in oil. An aluminum casing makes the unit durable and light in weight. *2.*

Pneumatic Vibrator

A newly-developed pneumatic vibrator, featuring a vise-like head for quick, easy attachment to wood or metal structural members, is announced by The Cleveland Vibrator Company. Originally designed to settle concrete mixes, the new unit has many uses where portability plus high frequency vibration is important. A sturdy U-shaped head functions as a vise in clamping the unit to any 2x4, 2x6 or 2x8 in member. Operating speeds of the "Vise Grip" vibrator

ranges from 3600 blows per minute at 100 psi to 1000 blows at 50 psi line pressure. Air consumption varies from 5 to 10 cfm. A 360 degree swivel connector increases ease of handling and positioning and prevents hose kinking. *3.*

Quick-Operating Air Control Valve

A new, compact, quick-operating air control valve is announced by Ross Op-

All moving parts are controlled hydraulically by T-J Cylinders—on this Malleable Nut Production Machine designed and built by Roy Hays & Associates, Rockford, Ill., for the Wagner Malleable Products Co., Decatur, Ill.

It's *fully automatic*—the operator only places nuts in stations. Nine T-J Cylinders, 40 ton to ½ ton, help complete the job of cutting off sprue, sizing, boring, facing, chamfering and threading 2,500-¾ std. pipe thread nuts per hour.

For your tough jobs of power movement—pushing, pulling or lifting—*save labor, speed production* and *cut costs* with T-J Air and Hydraulic Cylinders! Many standard sizes and styles . . . both cushioned and non-cushioned types . . . 100 lb. or 50,000 lb. Precision-built for long-life dependability. Write for latest catalogs. The Tomkins-Johnson Co., Jackson, Mich.

T-J
TOMKINS-JOHNSON
RIVITORS AIR AND HYDRAULIC CYLINDERS CUTTERS CLINCHORS

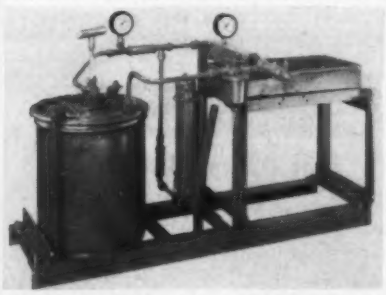
33 YEARS EXPERIENCE

erating Valve Co. Direct operated, using the standard Ross solenoid, the valve is useful for a wide variety of industrial applications. The new ⅛ inch pipe size valve is available in both normally open

and normally closed models, in straight-way or three-way, with in-line, side, bottom or panel mountings. The straight-way units are suitable for the control of liquids since corrosion-resistant materials are used throughout. All parts are easily replaceable. *4.*

Hydraulic Test Fixture

A bench type hydraulic test fixture for checking hose assemblies, piping, tubing, valves, gauges and cylinders has been designed and built by J. N. Fauver Co., Inc. A low pressure pump takes the



pressure to 100 psi, at which point the high pressure pump cuts in and takes test pressure up to 5000 psi. When the test is completed, the high pressure valve on the manifold is opened, draining oil through an edge filtration filter to reservoir. The reservoir holds approximately 3 gallons; higher pressure units are available. *5.*

New Ultrasonic Instrument

The Sperry Products, Inc., sales department announces a new model of Reflectorscope, their portable ultrasonic instrument for testing metals. Designated as Type UR, Style 50E351, the new instrument replaces the previous model, Type SR05. In addition to functional changes in styling and external design, modifications facilitate interpretation of test results; the latter is achieved by an improved pattern of square-wave "inch markers" on the horizontal axis of the screen. The new "Reject" control gives additional control of sensitivity by rejecting indications of small defects which do not affect the performance of the part or

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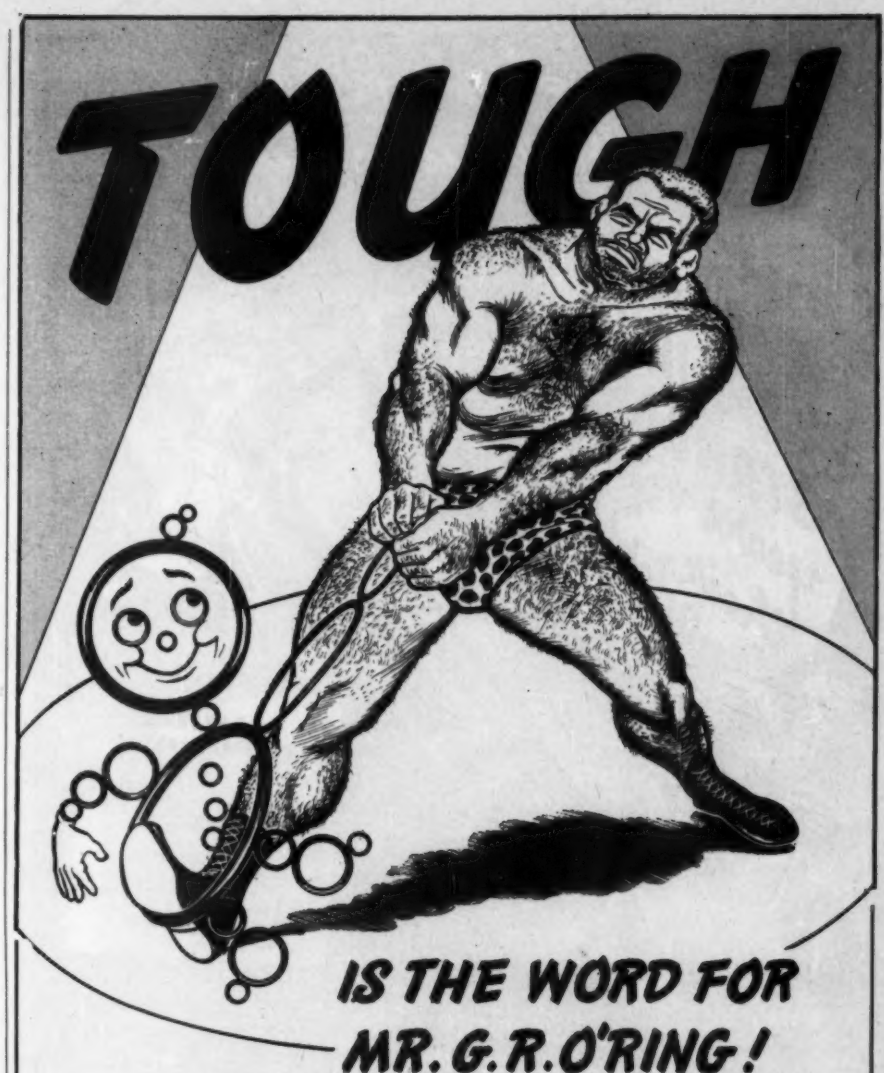

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Heat
- GRC "O" rings, compounded to hold up when the "heat is on", provide the solution to high-temperature sealing.
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- With high crush-resistance, low permanent set and accurate to close tolerances, GRC "O" rings insure perfect sealing.
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Friction
- Very low break-out, seizure, stain and adherence factors assure unfailing top-level performance.
- GRC "O" rings must continuously meet rigid specification tests to provide the best in sealing.

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- This unseen "killer" of "O" ring seals has met his match in seals molded from the GRC compound No. 1052 (AN-P-79)
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High Pressure Hydraulic Cylinders

met J.I.C.* HYDRAULIC STANDARDS years before their adoption

UNABRIDGED COPY of "Joint Industry Conference" Standards for specifying "quality" hydraulic equipment SENT FREE ON REQUEST

Why Experiment? . . . Specify Miller "Time Tested and Proven" Cylinders—And Be SURE!

***All* Miller Standard High Pressure Hydraulic Cylinders met both the *mandatory* and *recommended* practices of the "Standards" *years* ago.**

Some "Standards" specifications, such as dirt protectors, scratch-resistant piston rods, etc., are required only under severe conditions. *All* Miller *Standard* High Pressure Hydraulic Cylinders met *these* requirements *years* ago.

The desire for elimination of *manual* rod seal adjustment is strongly voiced at all hydraulic industry conferences. The *"time tested and proven"* Miller Patented Rod Seal is self-adjusting and wear compensating . . . *requires no manual adjustment.*

Complete Line

- **AIR CYLINDERS 1½" to 20" Bores**
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Single and Double Acting, Single and Double Rod End, Spring Return, Cushioned and Non-Cushioned, Over-Sized Rod, and Long Stroke Cylinders in All Mounting Styles.

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AIR AND HYDRAULIC CYLINDERS · ACCUMULATORS · COUNTERBALANCE CYLINDERS · BOOSTERS · AIR HOISTS

(Continued from previous page)

material under test. The Reflectoscope consists of a pulse-generator to generate short impulses of electrical energy, a crystal transducer or "searching unit"

to convert electrical energy into ultrasonic energy and reflected ultrasonic energy into electrical energy, an amplifier and a cathode-ray tube. A "sweep generator" provides a time base for the tube and a "marker generator" produces a square-wave trace to furnish a measurement of distance. The unit is used for testing a wide variety of machined parts, welds, billets, etc., and is useful to maintenance as well as production testing departments. *6.*

CIRCLE NUMBERS ON THE CARD AND MAIL!

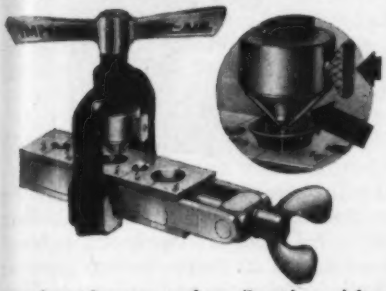
Foot Operated Air Valve

A new line of foot operated valves for control of single and double acting cylinders is announced by Mechanical Air Controls, Inc. The "MAC" foot valve line, available in ⅜ and ¾ in sizes, is designed to give the operator the option of using it either as a locking or non-locking type. Low treadle design, with a short and easy stroke, helps eliminate operating fatigue in the normal non-locking up and down pedal control.

Locking is obtained by a slight forward pressure of the toe with the pedal in the depressed position. The one moving part, a hard chrome spool has "O" ring seals which enter lapped bores of the body and end caps to effect instantaneous "sealed with air pressure" seal. *7.*

New Flaring Tool

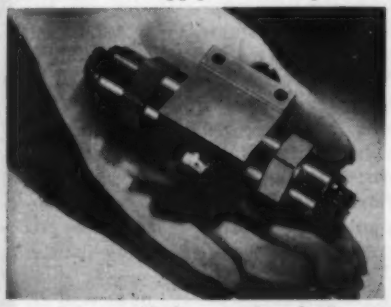
A new "Roll-Air" flaring tool, which both flares and burnishes copper, brass and aluminum tubing, has been announced by The Imperial Brass Mfg. Co. The new tool has three rollers in the spreader cone so that the flare is rolled out with the tubing extended above the face of the flaring block. Since the base of the flare is not formed against the die, the original wall thickness is maintained, giving a stronger flare, which the company states will



stand up longer under vibration. After the tubing is flared, it is burnished by turning the operating handle two more revolutions with control knob in burnishing position. The Rol-Air flaring tool flares ¼, 5/16, ⅜, ½ and ⅝ in tubing. *8.*

High Pressure Shuttle Valve

A 3000 psi shuttle valve which meets or exceeds aircraft requirements of Specification AN-V-3b, is announced by The Parker Appliance Company. Although produced primarily for aircraft use (designed in accordance with AN 6277 and AN 6278), the shuttle valve is applicable to industrial systems where it is desired to supply alternate pressure



sources to a cylinder or other devices as a precaution against emergencies for other design reasons. The new value, built in tube sizes 6 (⅜ in OD) and 8 (½ in OD), will shuttle against a closed line; the shuttle will not unseat from surge flows or negative pressures. The valves have a pressure drop of less than the allowed maximum of 10 psi at rated flow. *9.*

Air Operated Arbor Press

The air-powered arbor press offered by The Bellows Co. has been improved by the use of a specially designed double-acting air cylinder to provide full control of both the advance and retract strokes of the ram. The full control of air pressure enables the press to be used for the assembly of the most fragile parts. By means of a double-end piston, equipped with an adjustable locking

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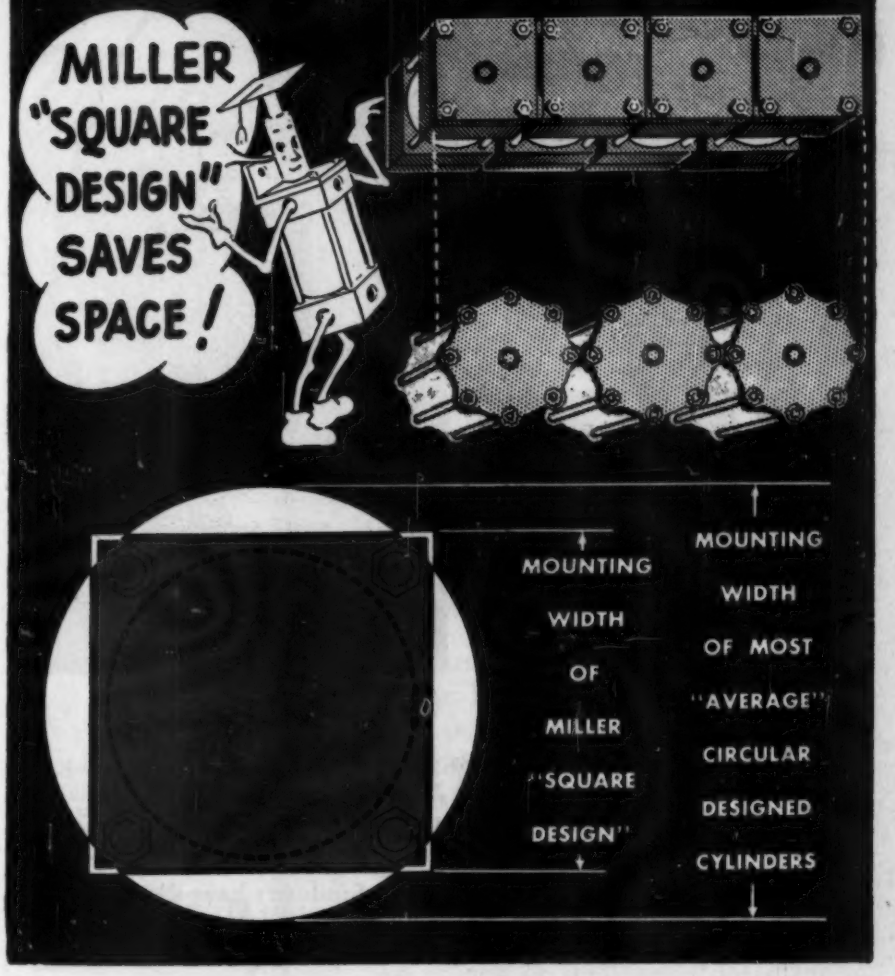
Miller

Air Cylinders
Hydraulic Cylinders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- **DIRT WIPER SEALS. Keep out abrasive dirt.**

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GREER ACCUMULATOR

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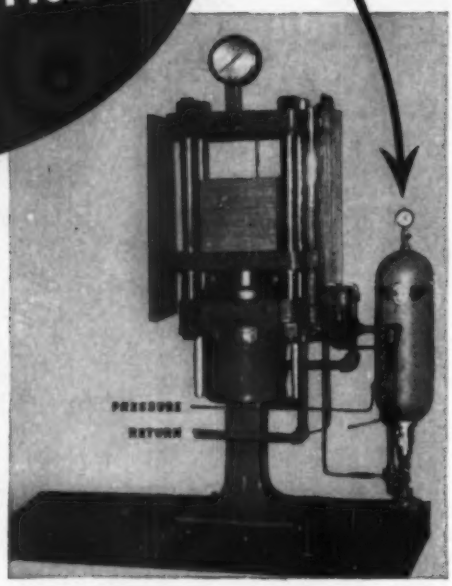

No matter what your press is used for: be it for Molding Rubber, Plastics, Ceramics, or Metal Scrap; you will find that the addition of a Greer Accumulator will greatly improve its performance and speed up its operation.

Many press users in every phase of industry have discovered that an inexpensive Greer Accumulator provides their presses a new answer to some very old problems:

- ECONOMY . . . Permits the use of *small pump and motor* to do the job of much larger ones, thus effecting a saving in floor space, operating cost and cost of original installation.
- FLEXIBILITY. . . Installed in *multiple press installations* operating from a central power source, accumulator eliminates pressure losses as presses are operated individually; thus eliminating work spoilage and costly rejections.
- SAFETY . . . Dampens hazardous *pump pulsations* and line surges and permits smooth operation of entire system.

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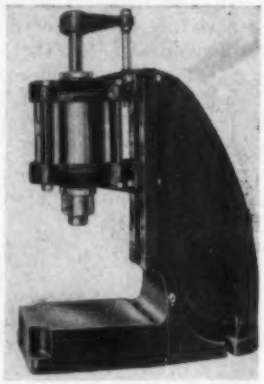
(Continued from previous page)

collar, positive adjustment of stroke length from a fraction of an inch to a maximum of 2½ in is obtained. Since the ram is held in a non-rotating position the press may be used for light die cutting or stamping operations where register is involved. Power thrust is approximately 20 times the line pressure applied; the press will operate on any air line pressure to 175 psi. *10.*

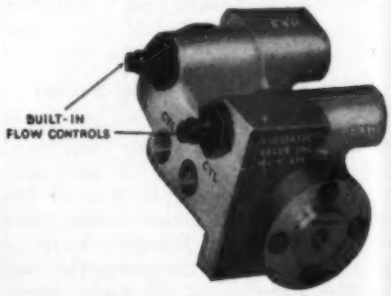


Safety Relief Valves

The line of positive acting air pressure relief valves offered by The Cornelius Company now includes three valves suitable for gas relief pressures from 75 to 3000 psi. The valves employ a spring balanced piston which carries a stainless precision ball seating within the piston. As pressure is applied, the piston moves against the spring and the ball seat closes more tightly as the pressure increases. When the pressure blow off setting is reached, a stationary adjustable and sealed pin forces the ball from the nylon seat, permitting excess pressure to escape. Model 116-B-100 valve is adjustable for cracking pressures between 1500 psi and 3000 psi; Model 117-B-100 valve is adjustable for cracking pressures between 1000 psi and 2000 psi; and Model 118-B-100 valve is adjustable for cracking pressures betwen 50 psi and 500 psi. All three relief valves are of the same design except for the different sizes to accommodate various cracking pressures. The design allows a very low relative differential between cracking and absolute reseating pressures. *11.*

Flow Control Valve

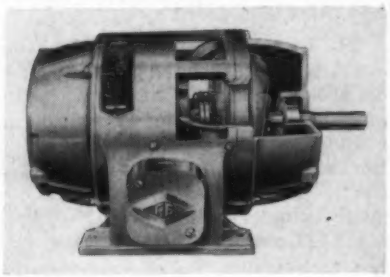
Airmatic Valve, Inc., announces a new, compact type Master air and low pressure hydraulic valve with built-in full capacity flow control meters of venturi type. The Model MV-4-375 valve incorporates a one-piece balanced spool with aircraft packing, the design permit-



ting full line volume without any loss of pressure. Operation is not affected by line pressure variation. The valve can be close-coupled to the cylinder, saving air and pipe cost and increasing speed of operation. Model MV-4-375 can be used in conjunction with pilot valves to provide automatic and semi-automatic operation, sequence of operation and remote control paneling. The new design is available in four standard pipe sizes —¼, ⅜, ½ and ¾ in. *12.*

Fluid-Shaft Electric Motor

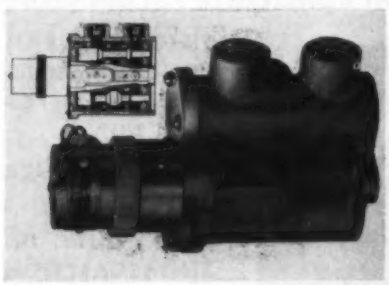
A new development in electric motor design, the Fluid-Shaft motor, is announced by the Reuland Electric Co. The units feature a single frame, integral design of motor and fluid-drive coupling, said to be the first such design. Both price and space savings are achieved over conventional electric fluid-drives, the new units utilizing regular motor frames and end bells. Fluid-shaft motors offer many advantages wherever loads require smooth acceleration, protection against "jamming" and



shocks or are difficult to start. The new motors eliminate the need for over-size motors for loads difficult to bring up to speed and considerably reduce the starting current. Sizes from ½ to 10 hp are in production. *13.*

Four-Way Control Valve

A new design, four-way, pilot operated, solenoid controlled valve for air, light oils and water is announced by Crescent Valve Company. The new valve, Model 1044, may be operated at

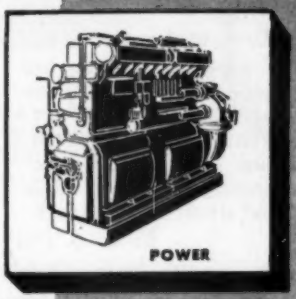


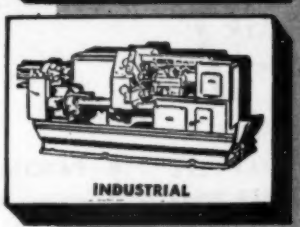
any cycling speed to 600 cycles per minute and is available in two types: for operation on line pressures 0-50 psi and pressures 30-150 psi. The two main valve members, vertically aligned with parallel bores in the valve body, move up and down simultaneously to open and close inlet and outlet ports. An auxiliary hand lever for occasional manual operation is available. Special design solenoids with covers adjustable through 360 degrees consume 21 w ac and 22 w dc. Four sizes, ¼, ⅜, ½ and ¾ in I.P.S. are available. *14.*

ROPER

ROTARY PUMPS

The Name of Dependability





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Whether your equipment is dependent upon a pump for fuel transfer, coolant work, or hydraulic action, you will maintain greater operating efficiency with the rugged Roper — Series F. This series is built to pump clean liquids of all kinds, and is available in standard or special-built designs in 1 to 300 g.p.m. . . . pressures to 300 p.s.i.

Standard-fitted pumps are self-lubricated by the liquid being pumped . . . helical gears of equal size run smoothly in axial hydraulic balance . . . precision ground and hardened drive shaft . . . 4-port design permits eight optional piping arrangements to cut down installation time and costs. Investigate dependable Roper pumps now and learn how they can help you in new or replacement installations. Send the coupon today!

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701 Blackhawk Park Avenue, Rockford, Illinois

☐ *Please Send Catalog 950*
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CITY_____
COMPANY_____

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

28. Steel Tubing Handbook . . . Technical Handbook No. F-3, "Fabricating and Forging Steel Tubing" devotes its 48-pages to the basic fabricating and forging operations and the size ranges of equipment at The Ohio Seamless Tube Company. Profusely illustrated by line drawings and photographs, sections on fabricating and on forging detail the wide range of types of work produced. Basic data on joining and mill practices and useful tables are included.

29. Rotary Displacement Pump . . . Catalog L21NT, issued by IMO Pump Division, De Laval Steam Turbine Company, gives full engineering data on the Series A21N IMO pump designed for flange or integral mounting. Design features, specifications, typical application photographs and a chart of capacities and power requirements are included. This series, which includes two sizes, is suitable for handling oil and other liquids at pressures to 100 psi.

30. Hydraulic Cylinder Assemblies . . . Hydraulic Equipment Company has issued a 4-page illustrated folder on standard design, single and double acting hydraulic cylinder assemblies. Complete specification data including recommended operating pressures, effective diameter and stroke required is included.

31. Desurger and Shock Absorber . . . A four-page bulletin offered by Valve Engineering & Development Company describes the "Fluidynamic" throttling desurges they manufacture. The desurger is designed to allow fluid flow and accumulation through throttling orifices so that pressure rise of a surge is throttled by pressure losses through the calculated size and number of orifices. For two directional flow surging pressures of 5 percent of the theoretical average pressure are easily obtained. Tank and high frequency pump (centrifugal, rotary-vane and gear) surges are effectively throttled. Data on four types and 11 model sizes are given.

32. "The Facts of Life" . . . Logansport Machine Co. announces the second printing of the pocket-size booklet, "The Facts of Life on Air and Hydraulic Devices" made necessary to supply the great demand for this practical manual on the "Do's", "Don'ts" and "What to Look For" phases of setting up and servicing this type of equipment. The material was compiled specifically as a service to designers, engineers and maintenance men. The reprint was made necessary by the great demand, greater than was anticipated.

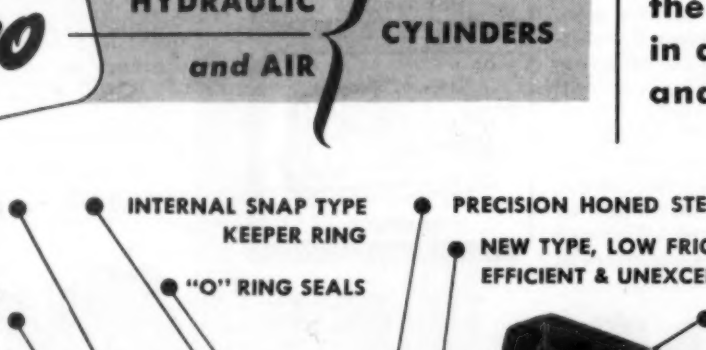
33. Molded Packings . . . Bulletin MP-20, issued by Greene, Tweed & Co., describes the all-purpose "Palmetto" vee-type "Pyramid" packing for stuffing boxes regardless of motion of rod, shaft or plunger as well as data on special purpose molded packings—"U-Ring", Kup and Flange packings. An application chart is included.

34. Directional Control Air Valve . . . A 6-page illustrated bulletin No. 10 describing the "Hi Cyclic" air valve that provides for complete control of air cylinder action has been issued by Beckett-Harcum Company. The "Hi Cyclic" valve will control the stroke of an air cylinder within .001 in; stop and

(Continued on page 40)

PEMACO — HYDRAULIC and AIR CYLINDERS

the last word in design and operation


AMPLE BRONZE BEARING
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NEW TYPE, LOW FRICTION PISTON SEAL—EFFICIENT & UNEXCELLED FOR DURABILITY
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PISTON AND RAM POSITIVELY SECURED BY PATENTED LOCK NUT
"SEAL GUARD" RAM SCRAPER POSITIVE PACKING PROTECTION
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50 ROCKWELL—HARDENED AND GROUND STEEL RAM—SCORE RESISTANT

PEMACO AIR CYLINDER

An exclusive feature is the one piece piston construction. Other makes using synthetic or leather cups usually have a piston made of three pieces...and thus cannot maintain 100% concentricity.

Send for full details on both *AIR* and *HYDRAULIC* cylinders.

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APPLIED HYDRAULICS DIGEST

Abstracts, summaries and listings of articles on hydraulic and associated applications in industry; reports on prepared papers, talk and discussions pertinent to the hydraulics field.

Abstracts of Papers Delivered at the Fifth Annual National Conference on Industrial Hydraulics

(Continued from December issue)

"Operating Hydraulics of a Large Water Supply System", **By F. G. Gordon,** Assistant City Engineer, City of Chicago.

This paper discusses the operating hydraulics of a large water supply system as it relates to methods employed to maintain an adequate hydraulic gradient over the system under varying conditions of supply and consumption.

The general arrangement of the system from source of supply to consumer is described and the distribution of territory served between steam and electric driven stations is outlined. Based on long term operating records—extensive enough to evaluate fully the item of maintenance—the relative economies of the two kinds of power are compared. This comparison is presented both for all stations of the same type, and for the most modern station of each type. Methods employed to maintain efficiency are recounted.

The result, hydraulically, of interposing a filtration plant between the source of supply and the pumping stations is discussed and the problems involved in maintaining a satisfactory hydraulic gradient through the filtration plant, under varying load conditions, are described.

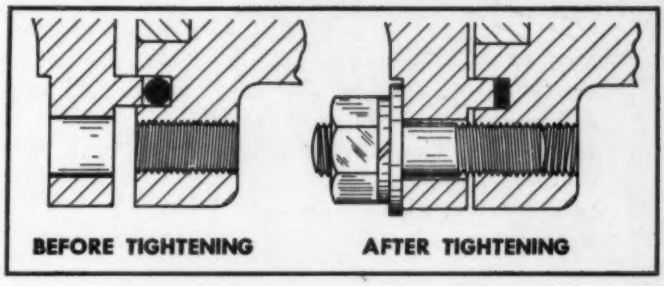
The paper analyzes the effect on the operating hydraulics of variations in consumption; as they follow daily, weekly and yearly patterns; or as they are influenced by other variables which, while known, can only be predicted in a general way as to magnitude and time of occurrence.

"Hydraulic Tracing Devices Used in the Machine Tool Field", **By Nagle V. Gusching,** The Monarch Machine Tool Company, Sidney, Ohio.

The ability of hydraulic tracing devices to contour and profile rapidly and accurately has enabled the machine tool industry to design many of its metal-cutting machines to bring high production manufacturing economies to even relatively small lot operations. Lathe designers, in particular, in developing the concept of "single tool turning", have pushed contour duplicators, previously limited to a role in the tool and die shop,

(Continued on page 43)

Prevent Gasoline Leakage Even at Temperatures of −55°C. to +70°C.



A primary consideration involved in the design of this Eclipse-Pioneer Autosyn* Fuel Flow transmitter was sealing the metering chamber to prevent gasoline leakage under *all* conditions. This transmitter had to operate satisfactorily over a temperature range of −55°C. to +70°C. This meant that a seal had to be selected that would not become brittle at extremely low temperatures and permit gasoline leakage.

Eclipse-Pioneer engineers state . . . "The simplified installation, low cost, and efficient sealing action of Linear "O" Rings have all been contributing factors to a practical solution of a very exacting problem."

In addition to being compounded of natural and synthetic rubber, Linear "O" Rings are also available in Kel-F or Silicone to resist actions of vigorous oxidizing materials over wide temperature ranges.

If you have a design or production problem calling for dependable sealing under extreme operating conditions, Linear "O" Rings may help you solve it. For low packing costs and high sealing efficiency CALL LINEAR.

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"PERFECTLY ENGINEERED PACKINGS"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA

Ledeen heavy duty cylinders helped do this job better

FLOW CONTROL OF POWDERED PLASTIC TO MOLDS AND PRESSES

APPLICATION—Finely powdered plastic chemical is stored in bins; must be fed accurately to molds and presses. Bin valves at the bottom of each hopper are operated by 4" diam. x 8" stroke Ledeen cylinders. The resulting control of material flow is both accurate and fast.

OPERATION—The cylinders are air operated, and all valves are remote controlled. Each cylinder is suspended vertically from the frame by its upper cylinder head; attached to the bin valve crank by a clevis on the piston rod. Vertical adjustment is provided to assure accurate opening and closing.

Perhaps you too have a job that can be improved by Ledeen heavy duty cylinders.

Wherever you have to...

PUSH OR PULL, LIFT OR LOWER, PRESS OR SQUEEZE, TILT OR TURN, OPEN OR CLOSE,

Ledeen heavy duty cylinders, operated by air, oil or water, will do it for you better and surer.

Standard Ledeen Cylinders with rod or head attachments are available from distributors' stock in major cities. Special cylinders on order.

Write for Bulletin 453.

LEDEEN CYLINDERS ARE GOOD CYLINDERS • LEDEEN CYLINDERS ARE GOOD CYLINDERS • LEDEEN CYLINDERS ARE GOOD CYLINDERS

Ledeen Mfg. Co.

DIV OF ENGINEERING PRODUCTS CO

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(Continued from page 38)

return the stroke at any point without overtravel; control the speed of stroke in either direction; reciprocate mechanically or electrically; control the pressure of both ends of the cylinder and effect a great saving in air. The basic valve, dual exhaust or five-port valve, single and double solenoid valves, piloted valves and four-way hydraulic valves are included.

35. Hose Couplings and Fittings ... Bulletin No. 300-1 gives full information on the "Dalbo" line of air hose couplings and fittings offered by The Dallett Company. Three lines of couplings; machined from the solid in steel and brass and cast from brass, are shown, as are also air hose and air valves and fittings. A complete line of industrial sizes are listed.

36. Tube Fittings . . . The Parker Appliance Company has issued Catalog No. 203 on their "Industry Standard" tube fittings and tube fabricating equipment. Sections are devoted to Triple-Lok tube fittings (3-piece flare type in steel and type 316 stainless to meet AN-F-47 and J.I.C. standards), Triple tube fittings (3-piece flare type, made in brass for normal wall thickness copper tubing), Triple XX tube fittings (for heavy wall copper tubing), Ferulok tube fittings (flareless "bite" type, made in steel with Dryseal pipe threads for heavy wall tubing to meet AN-F-7 and J.I.C. standards), steel and brass pipe fittings. Tubing and tube clips, seamless steel tubing and tube fabricating equipment are shown. Full specifications are given throughout the 56-page manual, which is well indexed and generously illustrated.

37. General Purpose Valves . . . Six page folder No. 1-48, issued by Atkomatic Valve Co., Inc., describes nine types of electrically operated valves for oil, water and air. Valves for continuously operating pressures to 300, 500 and 3000 psi in sizes from ¼ to 3 in are shown. A number of application suggestions and list prices are also shown.

38. Portable Oil Filter . . . Data sheets on portable model AF-2000 oil filter are available from General Filters, Inc. This full-flow design filter, designed

THE MARKET PLACE

CLASSIFIED ADVERTISING

Rates: For "Positions Wanted" $4.00 minimum, limit 25 words. For all other classifications $4.50 minimum for 25 words, each additional word 15c; bold face type or all capitals, $7.50 minimum for 25 words, each additional word 20c; limit 50 words. Box addresses count as five words. All insertions are payable in advance.

These columns are limited to Help Wanted or Position Wanted ads, and offerings of used equipment by the users of such equipment.

Hydraulic Cylinders, Double acting, 2½" Bore, 16½" travel, 1 3/16" shaft, ¼" pipe thread ports, Brand New $11.00 each, plus transportation. Shipping weight 10 pounds. Discount on ten or more. Spencer Aircraft, 8410 Dallas, Seattle, Washington.

CONSULTING ENGINEER

Specializing in hydraulic, pneumatic, electrical control circuits. Schematic circuits, complete machine designs. Unbiased equipment recommendations. P. H. Winter, 109 Archer Road, Syracuse, N. Y.

PRACTICAL AIRCRAFT HYDRAULICS

51 COLORED illustrations. Diagrams of the DC-3, DC-6, Constellation, and Convair-Liner. Easy to understand. World Press, 1817 California Street, Denver, Colorado. $3.85 Postpaid.

QUALIFIED HYDRAULIC ENGINEER

A well rated mid-western manufacturer, employing 200 persons, located in a pleasant industrial community of 75,000, has a good opening for a well qualified engineer.

Man selected must have had five to ten years experience in the development of hydraulic circuits for varied applications. In his background he will have a degree in mechanical or electrical engineering.

Principal duties—to act as consultant for a nation-wide organization of hard hitting special representatives needing assistance in engineering on the use and application of a full line of hydraulic pumps, valves and related products. Some travel is involved.

Present organization forms a well-knit congenial background in which each individual has a wide latitude to develop his ideas and opportunities. Starting salary $5,000.00 to $6,000.00 range.

Submit full information with first letter; age, family status, present employment and position. Nature of connections since leaving college. Photo desirable. All data held strictly confidential. Our own people know of this advertisement. Address Box 1150, Applied Hydraulics.

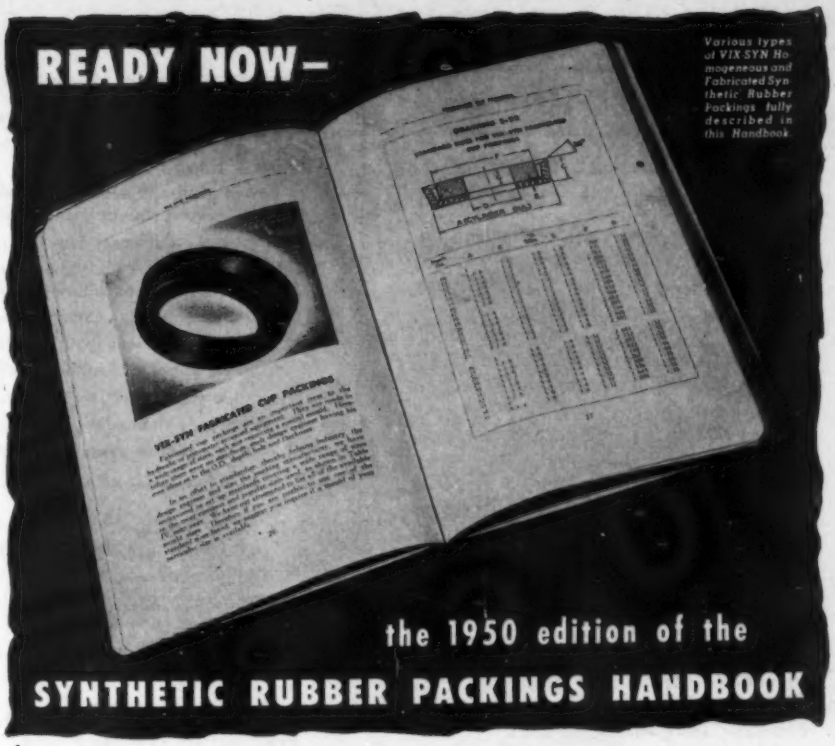
Revised to include new packing standards, developed by Houghton

Nearly everyone interested in hydraulic design is familiar with Houghton's authoritative handbooks on leather and synthetic rubber packings. Thousands of copies are being regularly used for reference by design engineers — so many that our stock has been exhausted for months.

Houghton purposely delayed reprinting because of the changes which would be necessary when packing standardization—pioneered by our engineers—was finally approved by the Joint Industry Conference.

Now the new handbook on synthetic rubber packings has been completed, including dash numbers for easy ordering of standard sizes, plus other data added since the first edition was compiled. You may have a free copy by writing us on your letterhead, or filling in the coupon below.

And please bear this in mind—that the engineering knowledge necessary to compile such a handbook will be most helpful to you when you reach the point in design work of having to include an effective packing installation. So use Houghton's experience, and Houghton's packings. We make all types—will recommend the best for your particular application.


READY NOW—
Various types of VIX SYN Homogeneous and Fabricated Synthetic Rubber Packings fully described in this Handbook.
the 1950 edition of the
SYNTHETIC RUBBER PACKINGS HANDBOOK

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303 W. Lehigh Ave., Phila. 33, Pa.
Please send the new VIX-SYN Handbook to

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Company.....

Address.....

originally for aircraft engines, has been further developed for industrial use. Capable of filtering 2000 gallons of standard hydraulic oil per hour at 70 F, the unit may be equipped with screens or other filtering media for filtration areas between .040 in and 5 microns. Full specifications are given in the data sheets.

39. Tubular Exchanger Standards . . . A new second edition of the 94-page manual on "Standards of Tubular Exchanger Manufacturers Association" has just been published by this Association. Of value to those concerned with the design, manufacture, specification, purchase, operation or maintenance of tubular exchanges, the manual authoritatively covers such subjects as heat transfer and pressure drop data, thermal properties of fluids, characteristics of tubing, temperature and temperature differences, fabrication and performance, commercial and general process applications and installation, operation and maintenance. Copies are available at actual cost of $3.00 for paper cover or $4.00 for fabricoid covers.

40. Pipe Line Shock Absorber . . . A new bulletin just issued by R-S Products Corporation features four models of the Heyden liquid shock absorbers offered by this company. The unit, designed to eliminate hydraulic shock and hammering in both water and oil pipe lines, has no moving metal parts—shock is absorbed by means of a rubber cushion encased in a spherical chamber. The cushion pulsates constantly as system pressure increases or decreases. The industrial model will withstand an internal pressure in excess of 3600 psi. The units are foolproof, practically indestructible and easy to install in any position.

41. Pressure Regulating Valve . . . Bulletin NP-1005, issued by Hannifin Corporation, describes the "Air Warden", a new air pressure regulating valve. The valve offers a number of features for the first time at moderate cost. Two sizes, ⅜ and ½ in pipe sizes for maximum primary and secondary pressures of 150 and 125 psi are shown.

CIRCLE NUMBERS ON THE CARD AND MAIL!

42. Relays . . . A new 12-page Relay catalog No. D-20A has just been issued by the Ward Leonard Electric Co. Seven standard types of magnetic relays for industrial and general purpose contral applications are illustrated and described. Complete technical data on relay ratings, dimensions, coil specifications and applications is included.

43. Truck Tailgate . . . Bulletin No. BH-49160, issued by The Heil Co., describes the Heiloader, a hydraulically operated truck tailgate for use on 1½ ton and larger flat bed trucks. With a lifting capacity of 2000 pounds at a speed of 50 inches in less than 10 secands, the unit is capable of 30 to 50 percent saving in stand-by loading and unloading time. The self contained hydraulic system is equipped with an automatic safety by-pass valve to prevent damage due to possible overloading.

44. Pump Coupling . . . Form No. 27-328, "Engineering of the Pump Coupling", issued by the Falk Corporation as a supplement to their larger and older Bulletin 4100 on the Falk "Steelflex" couplings, outlines an engineering problem of a pump installation considering: (1) hydraulics; (2) details of structural elements; (3) strength of materials; (4) and power requirements. The method of stating and solving the problem in five logical steps should be of particular interest to operating engineers and maintenance departments.

45. Cutting Production Costs . . . A pocket-size 64-page bulletin PG 4910, "Cutting Production Costs with Electronic Controls," issued by Photoswitch Incorporated, covers forty-five case studies of industrial control problems and their solutions through the use of electronics. A diagrammatic or system sketch, a statement of the problem involved and a description of the equipment or circuit required is included in each case. Cross references to technical literature and a good index makes the bulletin a very useful source for many types of industrial control problems and their solutions.

BOOK REVIEWS

Oil Hydraulic Power And Its Industrial Applications

Walter Ernst, *hydraulic consulting engineer, vice-president and director of engineering, The Commonwealth Engineering Co. of Dayton, Ohio. 366 pages, 6 x 9 inches. Published by the McGraw-Hill Book Company, at $6.00.*

This book is an excellent text and reference work, both for the practicing engineer as well as for the service man who wishes to acquire a greater knowledge of basic hydraulic theory. The first portion of the book deals with fluid mechanics as it is applied to practical hydraulic problems. This section has been excellently prepared, giving sufficient theory and basic laws to cover the subject, yet written in such a way as to be easily understood. A number of sample calculations are included to illustrate the practical application of the basic laws and formulae.

The second portion of the book offers a broad coverage of industrial hydraulic equipment, with proper emphasis placed on the fundamental components as well as on the design of the complete units. This section also includes sample calculations as well as typical efficiency curves and other useful data.

The final portion of the book deals with typical hydraulic circuits used in various industrial applications. This includes the use of solenoid operated valves as well as typical servo-mechanisms now coming into wide usage for machine tools and other hydraulic machinery.

Aircraft Electrical Systems, Hydraulic Systems and Instruments

Col. R. H. Drake, *research engineer, pilot and ground school instructor. 393 pages, 6¼ x 9¼ inches. Published by The MacMillan Company at $5.60.*

This book has been written for use in college vocational courses, trade schools, junior colleges, high school and in rehabilitation programs and aviation ground schools. Written in nontechnical language, it fills a definite need for a single volume covering these three important phases of aircraft auxiliary equipment. The text is divided into three sections, one covering each of the basic subjects. Each section is then subdivided into chapters dealing with basic fundamentals, types of equipment and types of systems. The author makes full use of illustrations and schematic diagrams, each of which is fully explained in the accompanying text. It is unfortunate that many of the equipment items illustrated have already become obsolete. This, however, should not be taken as a criticism, but rather as an

(Continued on page 44)

Basic Hydraulics Questions, Chapter 4

1. What are the most important characteristics of a good pipe system?
2. Explain the conditions determining what materials shall be used for piping or tubing in a hydraulic system.
3. How is pipe and tubing of different dimensions distinguished? What is the difference between standard and double extra strong pipe?
4. What is the difference between male and female threading?
5. What is meant by the radius of curvature of a pipe? What should be the radius of curvature of a pipe whose inside diameter is 3 inches?
6. How is permatex or other anti-seize compound applied?
7. Describe the various types of flanges and the conditions under which they are used.
8. Describe compression fittings, including flaring and annealing.
9. What is pickling?
10. How is pipe cleaned?
11. Why are gaskets used? Of what material are they composed?

NEW! DIFFERENT! NEW! DIFFERENT! NEW! DIFFERENT!

Effortless AIR CONTROL VALVES!

NEW! DIFFERENT! NEW! DIFFERENT!

Hand Operated

TYPE NH—A new hand-operated, four-way, directional air control valve. Sizes ½" and ¾". 3/8" lever motion.

Foot Operated

TYPE NF—A new foot-operated, four way, directional air control valve. Sizes ½" and ¾". With or without pedal guard.

HERE is the newest thing in air valves for operating single or double acting air cylinders! Built for *hand or foot* operation, these instant-acting valves provide fast, effortless control comparable to an electric valve—*at minimum cost.*

DISC TYPE; SELF-LAPPING—Metal-to-metal seat. Air tight. Packless.

PILOT CONTROLLED; PISTON OPERATED—Only light touch required; air does the work—shifts the main valve.

PRECISION ENGINEERED—Simple, compact, self-contained; rugged! Try one today. *Ask for bulletins.*

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BETTER BRONZE PARTS FOR ALL TYPES OF PUMPS

American Crucible methods, know-how, experience and equipment not only result in highest quality parts but also permit attractive savings to you.

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of the specific formula best suited to each application. That's why they carry a

MONEY-BACK GUARANTEE OF LONGER SERVICE—LOWER MAINTENANCE COST

PROMET BRONZE BAR STOCK

Round, hexagon, square. Rough cast or semi-finished. Cored stock all sizes (by ⅛" steps) from ½" minimum core to 12" O. D. and 13" lengths.

Write for literature or let us quote you and make recommendations. You are invited to submit blueprints, conditions of operation and other data.

THE AMERICAN CRUCIBLE PRODUCTS CO.

1303 Oberlin Avenue • Lorain, Ohio

(Continued from page 41)

into extraordinarily important applications in the field of mass production machines.

The method of producing the contour path, as described by the tool or cutter, is essentially the same in all tracing devices, different not in theory, but in application. A discussion of the basic principle underlying component of double component tracing devices will be undertaken.

Control circuits of hydraulic duplicating devices employ two general principles—the continuous-proportional system and discontinuous control means. As the former has attained the greatest perfection and acceptance, its characteristic advantages and limitations will receive major attention in the paper.

While the continuous-proportional type of control system is widely applied in the machine tool field, the exact nature of the various mechanisms differ widely.

"Large Hydraulic Valves", **By J. Fisch,** S. Morgan Smith Company, York, Pa.

This paper summarized the size limitations, the practical allowable heads and the current design practices for the various types of valves used in hydraulic installations. The large hydraulic valve field was defined, the general classes listed and their uses stated and various valves in each class were discussed in detail. These included gate, butterfly, rotary plug and free discharge valves. Plain sliding, ring follower, paradox and ring seat types of gate valves were discussed and the advantages and disadvantages of each were given. Butterfly valves were subdivided into the true butterfly valves and the Dow disc arm pivot valves. Cone plug and spherical plug types of rotary valves were discussed. Three types of free discharge valves were investigated: the needle valve, the hollow jet valve and the Howell-Bunger valve. Hydraulic and friction forces of operating mechanisms for various types of valves and their size relative to the size of the waterway controlled were discussed; electrical, hydraulic and manual operating devices were discussed for each type of valve. Completely automatic operation of rotary plug valves as emergency check, pump discharge, pressure regulating, etc., was outlined. Examples of actual installations of a number of different types of valves were given together with operating experience gained from them.

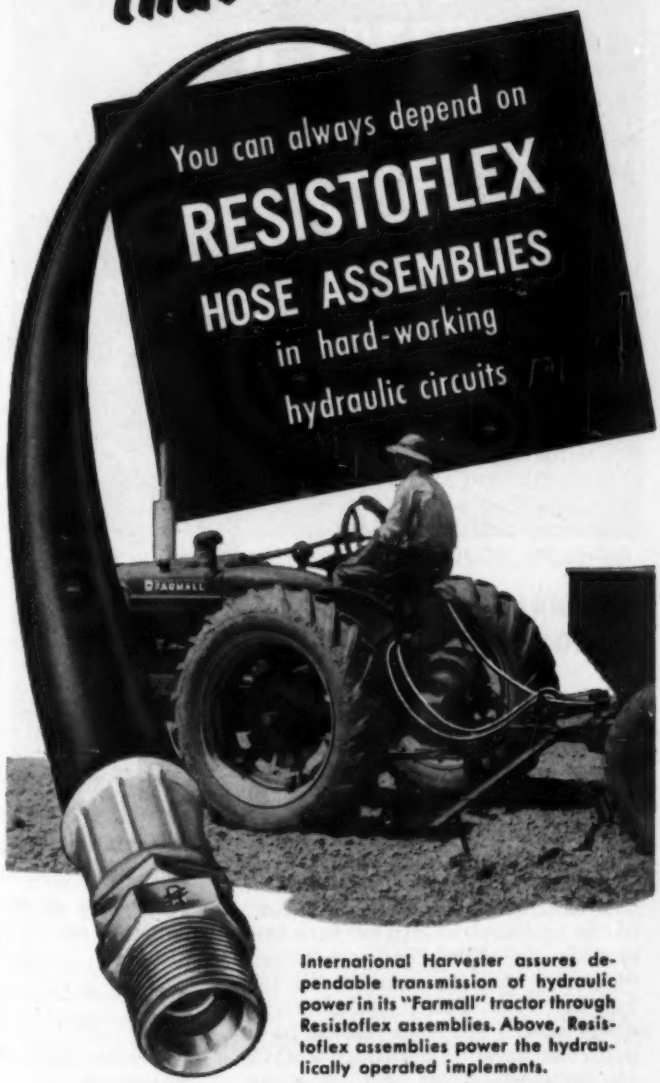
"Comparison of Hydraulic and Electric Servomotors", **By George C. Newton, Jr.,** Massachusetts Institute of Technology, Cambridge, Mass.

The term "servomotor" was defined and used to apply to the apparatus which supplies the major part of the power to the load in closed-cycle automatic control systems. The paper reviewed several basis considerations concerning the load and servomotor properties and presented an elementary discussion of the relationships existing among the servomotor properties. It was shown how a first approximation to the servomotor size may be made, knowing the load specifications and the interrelationships among the servomotor properties and the procedure for estimating servomotor size requirements by two numerical examples was illustrated.

Examples were given to show that, under certain

(Continued on page 45)

Need a Hose that can take it?



International Harvester assures dependable transmission of hydraulic power in its "Farmall" tractor through Resistoflex assemblies. Above, Resistoflex assemblies power the hydraulically operated implements.

You won't find many applications tougher on flexible hose than a farm implement. Yet, despite the constant movement, vibration and exposure, Resistoflex assemblies don't quit. These top grade lines keep hydraulic circuits functioning at full efficiency—keep a machine on the go. Any time you assure that kind of service, you can take customer satisfaction for granted.

Chances are that Resistoflex lines can do an outstanding job for you, too. Not only are they completely unaffected by flexing and vibration, but they're really impervious to hydraulic fluids and oils too. You run no risk of clogged mechanisms with this non-eroding hose.

Learn more about why Resistoflex lines insure against excessive replacements and service complaints. Write us about your flexible line problem *today*.

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SYNTHETIC FLEXIBLE PRODUCTS AND PARTS FOR INDUSTRY

AIR CONTROL VALVE

- ROTARY TYPE
- HAND LAPPED
- ¼" PIPE PORTS
- 3- or 4-WAY
- LOW-PRICED

Thousands of N. P. hand operated Control Valves are controlling air pressure on buses, street cars, subway and elevated cars, where their dependability is essential to the safety of passengers.

Quantity production of this high-quality valve makes possible its unusually low price. For complete information, write for Bulletin No. DC-204

NATIONAL PNEUMATIC CO., INC.
Industrial Division
125 Amory St., Boston 19, Mass.

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Pneumatic Specialists Since 1904

New GENERAL FILTER
for Hydraulic and Lubricating Oils

NO CARTRIDGES TO REPLACE

There are no expensive cartridges to throw away or stock. Entire unit is cleanable. First cost is only cost.

EASY TO CLEAN

Just remove one nut and all spacers and screens slide off. Wash in suitable solvent and replace. It's as simple as that.

FILTRATION TO SUIT EVERY APPLICATION

Write! for prices and specifications. Describe your application.

This Model 1300 GENERAL FILTER can be made to filter solids from .040 inch to 5 microns by varying the mesh of the filtering screens. Comes in two standard lengths, 8 inches and 4 inches, but can be made any length to provide capacity between 5 and 50 gallons per minute.

GENERAL FILTERS, Inc.
12890 WESTWOOD — DETROIT 23, MICH.

(Continued from page 42)

indication of the progress of aircraft design which has advanced more rapidly than textbooks could be written. The basic principles utilized in much of the equipment illustrated have been altered only slightly in most modern designs so that the value of the text has not been altered materially by obsolescence. The book should be of particular value to mechanics studying for specialist ratings or CAA certificates, whether in classrooms or by self instruction.

F.O.H.

ASTE Industrial Exposition

THE AMERICAN SOCIETY OF TOOL Engineers will hold their Industrial Cost Cutting Exposition and annual meeting in Convention Hall and Commercial Museum in Philadelphia the week of April 10 to 14.

A survey conducted by the Society indicates that large, medium size and small companies all plan volumes of purchases in 1950 greater than in 1948. A summary of the survey indicated that 45 percent of all companies will buy more than in 1948, 35 percent will buy approximately the same volume, only 7 percent will buy less and 13 percent reported that they will buy "very little". Of particular interest was the fact that as many companies reported that they would buy machines, accessories and equipment to modernize present equipment as would buy new machines to reduce cost; the percentage was 64 percent in each case. An average of 54 percent plan to replace equipment and 27 percent plan to purchase new materials handling equipment.

The study was undertaken to provide a factual guide in planning the Industrial Cost Cutting Exposition.

Cleveland Engineering Society Holds Hydraulic Meetings

A SERIES OF FIVE MEETINGS ON hydraulics were held in November and December, sponsored by the Machine Design Division of the Cleveland Engineering Society. Held on Thursday evenings from November 3 to December 8, the meetings which were arranged and directed by E. M. Hoffman, president of E. Hoffman Engineering Co., were well attended by both experienced engineers and young men to whom hydraulics is a new field.

At the first meeting R. L. Hall, machine designer, Cleveland Equipment Works of The General Electric Company, reviewed hydraulic fundamentals; subsequent meetings and topics were—R. F. Hodgson, chief engineer, The Hydraulic Equipment Co., who spoke on pumps and valves; R. H. Schuman, development engineer, The Warner and Swasey Company, who discussed the control problem; John A. Lauck, vice president and chief engineer, The Pesco Products Division of The Borg-Warner Corp., who with other members of his staff conducted an inspection tour through the new Pesco plant and lead a discussion period on the J.I.C. Hydraulic Standards; and W. C. Butcher, chief engineer, The Bellows Company, who lead the discussion at the last meeting of the series on the advantages of hydraulic, pneumatic and mechanical systems.

R. L. Hall, who has been active in the hydraulic activities of the Cleveland Engineering Society, also acts as instructor in a new course in Industrial Hydraulics, which is being offered at Fenn College, Cleveland, one evening each week. A capacity group of students, all engaged in some phase of industry involving hydraulics, are attending the course.

(Continued from page 43)

conditions, the important load specifications may be reduced to *inertia, peak torque, peak velocity* and *peak acceleration*. In this case, the important servomotor properties are *peak power, and peak torque-squared to inertia ratio*. Certain conditions, in the form of inequalities relating the servomotor properties to the load specifications, must be satisfied in order to meet the load requirements. Servomotor properties are interrelated for a given type of servomotor; these conditions may be interpreted as constraints which determine the servomotor size. The interrelationships are studied for hydraulic, constant-displacement motors and electric, direct current, shunt motor. Calculations were made of hydraulic and electric servomotor sizes required for load specifications typical of a ship's steering gear and a gun mount power drive.

The industry's solution to the problem of providing error-detecting, power-amplifying and feed-back components will be graphically illustrated with specific descriptions of representative tracing devices which, because they are indicative of the general practice in the entire industry, will be confined largely to the turning field.

"Techniques in Transient Pressure Measurement", **By E. A. Nielsen,** University of Michigan, Ann Arbor, Michigan.

This paper describes the methods of measuring static and dynamic pressures in hydraulic systems, and the uses which are made of pressure-time curves. Detailed attention is given to the many different kinds of pressure pickups since these, more than anything else, affect the success of the instrumentation.

The measuring devices consist of pressure pickup units which convert pressure signals to electrical signals which in turn are amplified and recorded on a magnetic oscillograph or cathode ray oscilloscope. Until recently this process has been strictly a laboratory function requiring highly trained electrical engineers working with limited make-shift instruments. However, there has been considerable progress made in the development of pressure measuring devices in the past three years.

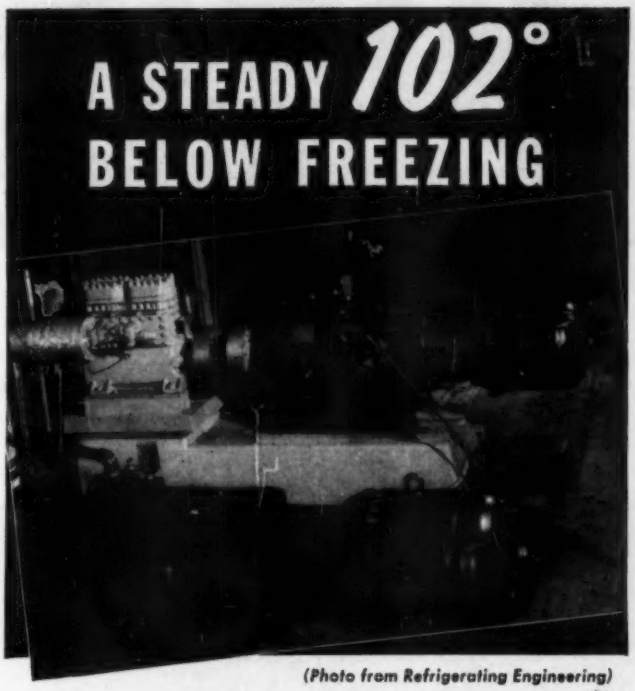
The pressure pickup is the heart of the unit. Many different approaches have been made in its design. Each of these may be generally classified into one of four types: resistance, capacitance, magnetic, or Piezo-electric. Each type has certain inherent advantages and disadvantages which are important to its application.

"The Design Problem of Turbomachinery", **By W. Spannhake,** Armour Research Foundation, Chicago, Illinois.

This paper presents a survey of our present knowledge of the flow through turbo-machines and the methods of design used to obtain proper operation and efficiency.

The basic theory of Euler—the one-dimensional one—is explained as a starting point for the design, and its application to all sorts of turbomachines is discussed. After describing the problems which can be solved by this theory, its shortcomings are shown by mentioning all questions which cannot be answered by it. The modern fashion of the theory is then established in a gen-

(Continued on page 47)



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POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

Jules P. Kovacs has been elected vice president and chief engineer of Purolator Products, Inc. He joined Purolator in 1929 as a design engineer and was named chief engineer in 1941. He is a member of the SAE A-6 Committee.

The Los Angeles office of The Rucker Company has moved to larger, more modern space at 1855 Industrial St., according to Alfred Dillon, Jr., southern branch manager.

Neilson Hydraulic Equipment Co., 444 Fourth Ave., New York City and Air Parts, Inc., Glendale, Calif., have been appointed as distributors for "O" rings by The Parker Appliance Company. Air Parts, Inc., located at 723 Sonora Ave. will also draw on factory stocks of the Parker Los Angeles plant.

Stephen C. May has been named vice president and general sales manager of Blackmer Pump Company, according to an announcement by B. L. Gordon, president.

The Test Equipment Sales Company, Inc., has been appointed agent for the Meletron Corporation in the Philadelphia area and M. S. Jacobs and Associates agent for the same company for western Pennsylvania and some adjacent territories, according to an announcement by George A. Starbird, president, Meletron Corporation.

A. M. Shaw has been appointed assistant manager, Pump and Compressor Merchandising Division, according to an announcement by F. J. Whelan, vice president, Worthington Pump and Machinery Corporation.

Andrew Kalitinsky, chief engineer, NEPA division, Fairchild Engine and Airplane Corp., Oak Ridge, Tenn., was awarded the 1948 Manly Memorial Medal, SAE, for his paper "Atomic Power and Aircraft Propulsion", which was presented at the National Conference on Industrial Hydraulics in October as well as before several sections of SAE in 1948.

Walter J. Herbut has been promoted to the post of chief tool engineer of Auto-Diesel Piston Ring Co., according to an announcement by R. D. Smith, vice president and general manager.

Homer A. Goddard, Jr., has been named assistant general manager for industrial marketing for Gulf Oil Corporation. H. G. Meador, vice president of divisional sales, in making the announcement stated that Goddard's new post, a part of the firm's new marketing program, makes him responsible for sales to industrial plants and organizations.

E. A. Thornwell, Inc., Atlanta; Ranson, Wallace & Co., Charlotte; Ambos-Jones, Cleveland; Butler

(Continued on page 48)

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All types of manually and mechanically operated valves are also available.

- "OU" TYPE PACKER.
- STANDARD PIPE SIZE AREA THROUGH VALVE.
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3-way piped exhaust double solenoid-operated valve.

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Builders of the famous Hufford Hydraulic Stretch-Wrap Forming Machines, Hydraulic Ceramic Presses, Hydraulic Elevators, and Specialized Hydraulic Machinery.

(Continued from page 45)

eral way and the real problem of determining the flow through turbomachines is demonstrated. All methods of attacking this three-dimensional problem and their effects upon the design of the machines are exhibited. Radial flow, mixed flow, and axial flow runners both for incompressible and compressible fluids and turbo torque converters are reviewed. The effect of viscosity, turbulence, and vorticity upon the pattern of the flow, particularly by setting up cross flows in between the runner blades and guide vanes is made evident and possibilities to minimize them are shown. As a significant example of a highly turbulent flow the hydraulic coupling is discussed.

The present status of what has been accomplished up to the present time by theoretical and experimental research work in the field of turbomachines is explained and suggestions for further work are offered.

Hydraulics in Force Measurement

Anonymous, *Machine Design,* v 21, October 1949, pp 113-114.

Hydraulic force-measuring cells—called Emery cells after the designer—are described and a number of their many applications as integral parts of machines, test stands or apparatus to measure thrust of bearings, torque on housings, changes in weight and many other types of force are given. The hydraulic cell is essentially a hydraulic cylinder with frictionless pistons with a stroke of less than 0.005 in under full load. The fluid makes no contact with the piston but is sealed within the cylinder or cell as a layer about 0.03 in thick by a thin metal diaphragm against which the piston rests. Slight movement of the piston flexes the diaphragm and compresses the fluid, transmitting pressure to the indicating or recording device. The piston moves without friction because it is centered by a bridge ring that maintains a wall clearance of approximately 0.1 in and prevents distortion of the diaphragm in the annular clearance space. The hydraulic cell is inherently sensitive as a weighing device, a 5,000,000 pound capacity cell readily showing a sensitivity of 5 pounds. Simple, self-contained hydraulic scales are being used for many weighing purposes where bell cranks, delicate knife edges or pivots would be undesirable. The Tate-Emery indicator, used with the hydraulic cell, permits maximum sensitivity and accuracy by operating on the null principle, using a pneumatic force-balance system.

Bibliography on Gas Turbines

Ernest F. Fiock, National Bureau of Standards Circular 482, "Bibliography of Books and Published Reports on Gas Turbines, Jet Propulsion and Rocket Power Plants." A new and complete bibliography includes sections on turbo-jet and prop-jet engines, other types of gas turbines, intermittent or pulse jets, ram jets, rockets, jet-propelled helicopter rotors and propellers, compressors, turbines, combustion and combustion chambers, aerodynamics, metallurgy, machine and welding and ceramic materials in gas turbines. Copies are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., at 20 cents per copy.

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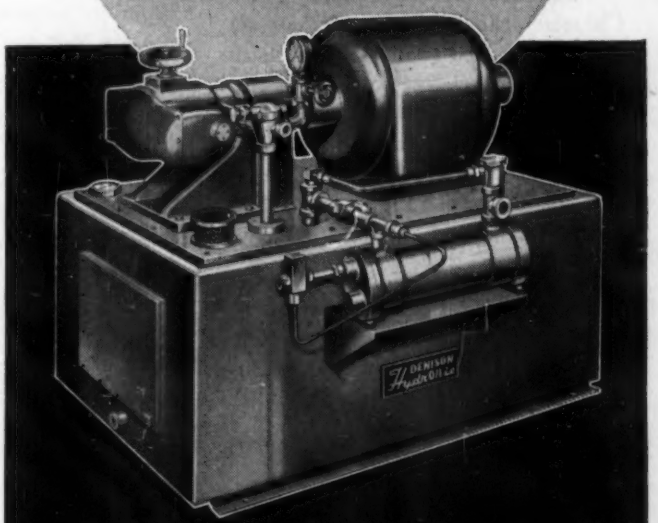

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Here's new, higher-level pumping efficiency—in 22 new models covering a wider range of hydraulic circuit needs.

These advanced HydrOILic Pumping Units offer maximum pressures to 5000 psi. Features include axial piston pumps in three sizes for either constant or variable volume operation, with volume capacities of 10, 20 and 35 gpm. Variable volume control is by handwheel, stem, or pressure compensation.

The rugged, welded steel reservoirs form the base of these new pumping units. Bottoms of all reservoirs are slightly raised and sloped, for easy cleaning and draining. All operating components, including electric motor, pump, relief valve, gauges and controls are mounted on a removable top.

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Many other features make these highly compact, amazingly *quiet* pumping units outstanding for industrial needs of every type. Write for complete details.

DENISON HydrOILics

The DENISON Engineering Co.

1166 Dublin Road • Columbus 16, Ohio

(Continued from page 46)

and Land, Dallas; Lynn Elliott Co., Houston; Curtis H. Stout, Little Rock; Geeseke and Pinkney, Minneapolis; Joralemon, Craig & Co., Philadelphia; J. E. Redmond Supply Co., Phoenix; and Riddle and Hubbell, Tulsa have been appointed district sales representatives for C. J. Tagliabue Corporation, subsidiary of the Weston Electrical Instrument Corporation.

Perfecting Service Company has moved from Chicago to their new plant in Charlotte, N. C.

Charles E. Sharp has been named Chicago branch industrial manager for Brown Instruments division of Minneapolis - Honeywell Regulator Co. He succeeds John A. Robinson, who has been named regional industrial sales manager for the Midwest and all western and Pacific Coast areas.

Air Associates, Inc., Dallas, Texas, and Independent Rubber Company, 665 W. Washington St., Chicago, Ill., have been named as distributors for "O" rings by The Parker Appliance Company.

Index to Advertisers

American Crucible Products Co., The 42
Berry Motors, Inc. 27
Brown & Sharpe Mfg. Co. 7
Commercial Shearing & Stamping Co., The 19
Cushman Chuck Co., The 23
Darling Valve & Mfg. Co. 9
Denison Engineering Co. 47
Electrol Incorporated 1
General Filters, Inc. 44
Goshen Rubber & Mfg. Co., Inc. 33
Greer Hydraulics, Inc. 36
Hanna Engineering Works ..... Cover 2
Hannifin Corporation 42
Hansen Mfg. Co., The 31
Houghton, E. F. & Co. 41
Hufford Machine Works, Inc. 46
Hydraulic Equipment Co. 2
Kenyon Instrument Co., Inc. 6
Ledeen Mfg. Co. 40
Linear, Inc. 39
Marvel Engineering Co. 8
Miller Motor Co. 34, 35
National Pneumatic Co., Inc. 44
Numatics 48
Oilgear Co., The 45
Ortman-Miller Machine Co., Inc. 48
Pesco Products Div., Borg-Warner Corp. ..... Cover 3
Petch Manufacturing Co. 38
Resistoflex Corporation 43
Roper Corporation, Geo. D. 37
Ross Heater & Mfg. Co., Inc. 4
Sundstrand Machine Tool Co., Hydraulic Division 5
Texas Company, The 10
Tomkins-Johnson Co., The 32
Valvair Corporation 46

B. J. Fletcher has been named assistant chief hydraulic engineer for Aluminum Company of America, effective October 1. Fletcher has been with the company since 1926 and since 1944 has been chief engineer of the company's development division.

The Hammel-Dahl Company, manufacturers of automatic control valves, announce that their control valves are now manufactured in England by the firm of J. Blakeborough & Sons Ltd., at Brighouse, Yorks, England.

The Midwestern Conference on Fluid Dynamics and the National Meeting of the American Physical Society, Fluid Dynamics Division, will be held jointly at the University of Illinois on May 5 and 6.

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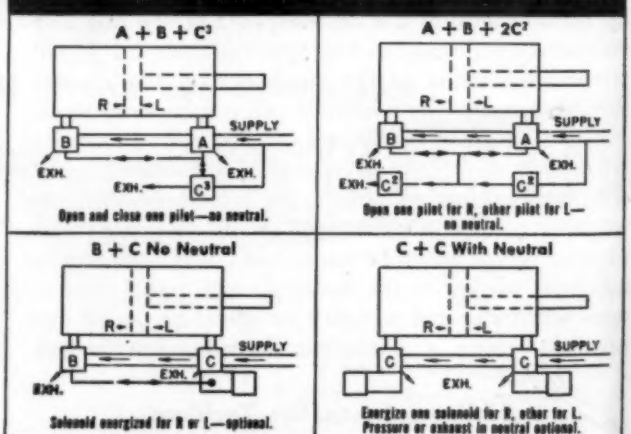

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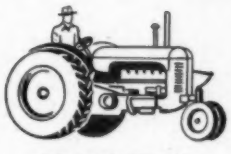

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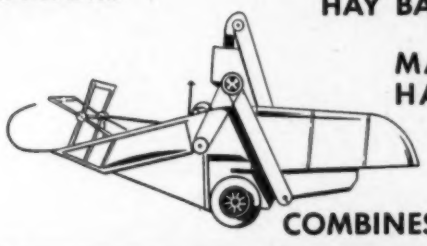

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